EFFECTS OF MECHANICAL PROPERTIES OF JUTE-SISAL/LFA REINFORCED EPOXY POLYMER HYBRID COMPOSITE

Sathish Kumar.G.K[1],Hemin Raja.J[2*],Ashok.K.G[3],Karthikeyan.S[4]
[1,2,3,4] Department of Mechanical Engineering, SRM Easwari Engineering College, Chennai,
E Mail: [2]heminraja.j@gmail.com

Abstract: Recent research on the use of natural fibres as replacement to man-made fiber in fiber reinforced composites have been increased and opened up further industrial possibilities due to advantages of low density, low cost and biodegradability. In this research work, an attempt was made on preparation of geopolymer composites (GPMCs). The geopolymer composites were made on wastes of Lignite Fly Ash (LFA) and naturally available fibers such as Jute, Sisal .The novel GPMC samples were prepared using the Hand Lay Up Technique at different weight mixing ratios of raw materials. The samples characterization was made by Scanning Electron Microscopy (SEM) studies to probe the microstructure and geopolymerization reactions. The mechanical properties Tensile Strength, Compression Strength and Flexural Strength values were reported on the prepared Geo Polymer Matrix Composites (GPMCs).It is inferred that, the alkaline treatment, prolonged curing and inclusion of Lignite Fly ash (LFA) significantly increases the compression strength ranges from 11.08 to 18.07 Mpa but reduces the ductility ranges from 9.5 to 11.31 MPa and the flexural strength varies between from 4 to 7 Mpa. Increase of addition of natural fibres and LFA ratios generally lead to lesser the tensile strength, flexural values and increase compressive strength than the pure epoxy polymer.

Keywords: Geo Polymer Composites, Natural Fibres (Jute, Sisal), Lignite Fly Ash, Scanning Electron Micron Scope, Mechanical properties.

1. Introduction

From centuries, mankind has used the natural fiber for various types of application including building materials. In most of the countries, users have explored the possibilities of using the natural fiber from different plants, which includes bagasse, banana, kenaf, sisal, jute, hemp, cereal straw, corn stalk, cotton stalk, rice husk/rice straw etc. Emergence of polymers in the beginning of the 19^{th} century has provided the researcher the new dimensions to use the natural fibers in more diversified fields. At the same time the necessity has also increased the interest in synthetic fibers like glass fiber which due to its superior dimensional and other properties seems to be gaining popularity and slowly replacing the natural fiber in different applications. As a result of this change in the raw material and production process of synthetic fiber based composites, energy consumption has increased. The environmental loss suffered by the society due to the pollution generation during the production & recycling of these synthetic based materials has once again drawn the attention for the use of natural fibers. The renewed interest resulted in the new ways of natural fiber modifications/use and brought it to be at par/superior to synthetic fibres. Now it is in use from making rope to spacecraft applications and the building industry has also come out as one of its main beneficiaries. J.A.M. Ferreira (2012) studied Impact response of Kevlar composites with nanoclay enhanced epoxy matrix. The laminates manufactured with epoxy resinfilled by 6 wt.% of nanoclays shown the best performance in terms of elastic recuperation and penetration threshold compared to the neatlaminates and the best performance in term of impact response obtained for the filled composites were also confirmed by the tensile residual strength which increases with filler content and the differences increase with the impact energy. According to the studythey used industrial hemp, epoxidized soybean oil (EMS) withunsaturated polyester and Results from this study indicate that novel multistage hybrid bio based composites can be obtained from acombination of industrial hemp and blends of unsaturated polyester with epoxidized methyl soyate and nanoclay inclusions also proper stiffness/toughness balance can be obtained by controlling the amount of bio-resin and nanoclay content. The improved multifaceted features possible forthese sustainable bio-based materials are likely to increase their appeal for use in transportation and housing structural applications.

2. Materials and Methods

2.1 Raw Materials

The preparations of proposed novel composite material started from the collection of raw materials includes matrix and reinforcement phases were obtained from different resources. The commercial grade LY 556 Epoxy resin is chosen as the matrix phase for this study. The properties of the epoxy are given in the Table.1. The qualified natural fibers extracts (reinforcement phase) of Sisal fiber from Chandra Prakash & Co,Jaipur (Rajasthan,India) Jute from Basu Jutex Pvt. Ltd,Kolkata (West Bengal, India). The received fibres extract from its parent plants in the form of long strand. The properties of received natural fibres are given in the Table.2 and all these data were provided by the suppliers of the fibres. The another proposed reinforcement in addition to natural fibres is Lignite Fly Ash (LFA) were personally collected from Neyveli Lignite Corporation (NLC) (Neyveli,India). The lignite fly ash used for this study is Class F* (low-Fe) type and the composition of the lignite coal fly ash match with the standard composition of the fly ash. Morphology examination of the Fly Ash powder and measurement of the sample powder particles sizes were carried out on OPTON (SEM) DSM 940 Scanning Electron Microscope (SEM). Sizes of the Fly Ash powder particles were determined based on SEM observations .It was found out that particles of powders used for this work is regular in shape and their size did not exceed 250 nm. The chemical composition detail of LFA is given in the Table.3.

Table.1 Properties of Epoxy

S.No.	Property	Value
1	Density (g-m^{-3})	1.15
2	Viscosity (m Pa S)	10000
3	Flash Point(˚C)	>200

Table.2 Properties of Fibres

Sample No	Name of the Fibres	Density (g/cm^3)	Tensile strength (MPa)	Elastic Modulus (GPa)
1	Sisal	1.5	511-635	9.4-22
2	Jute	1.3	300-700	20-50

3. Experimentation and Results

3.1 Tensile Strength

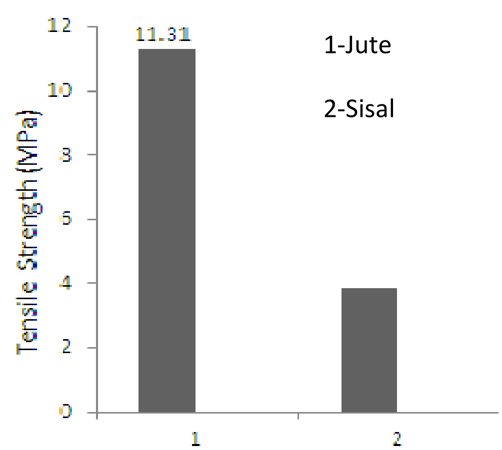

Figure.1. Tensile Strength of geopolymer composites

In order to understand the tensile strength the geopolymer composites were subjected to the tensile testing according to the ASTM standard. The prepared of size is subjected to the axial pull load. The tensile strength values of the samples are given is the figure.1. The fiber addition in the epoxy matrix keeps reduces the tensile strength of the material than the virgin epoxy resin. It is due to the placement of the fibres in the polymeric chain that resists the free movement of the polymers in the polymer chain. In the graph, the tensile strength is higher for Jute/LFA reinforced geopolymer composite than other composites. The addition of LFA particles provides the significant changes in the structure by increase the toughness of the matrix. The differences in the tensile strength in prepared geopolymer composites due to its orientation and compatibility in provided with lignite flash distribution in the matrix phase.

3.2 Compressive Strength

The compression strength is made on the prepared geopolymer samples according to the ASTM standard in Universal Compression testing machine and the effect of reinforcements in the epoxy matrix values for the given compressive load on the samples is shown in figure.2. It is observed that, there is a remarkable improvement is observed in the prepared geopolymer matrix composites other than Banana/LFA reinforced Epoxy composites. It may due to the higher deformation of the banana fibre and the position of the LFA particles in the matrix phase. Other all geopolymer composites showed the higher strength as compared to its tensile strength as shown in figure.1. In that cases, the alkali treated fibres/LFA posses the uniform distribution due to length-to-dia ratio of the fiber and the sub micron scale dimension of the LFA. The effective strengthen is proved for the good loading bearing ability of fiber in axial push direction and the organic oxide in LFA addition.

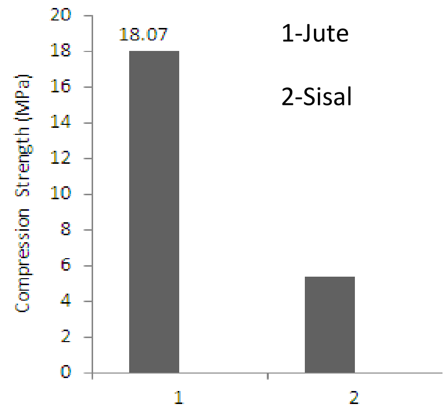

Figure.2. Compressive Strength of geopolymer composites

3.3 Flexural Strength

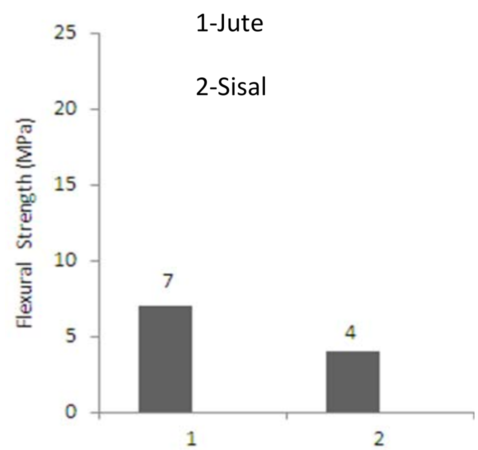

Figure.3. Flexure Strength of geopolymer composites

To analyze the flexural behavior of the prepared geopolymer composites the flexural test were performed on the prepared samples. For this the cured samples were cut in to long strips of standard dimensions. The three point bend test was contacted as per the ASTM standard with the displacement rate of 1.0 m/min. The four samples each of four combinations and the mean values were taken in to observations. The mean flexural strength values of the of the prepared geopolymer composites is shown in figure.3. It is observed that among all the flexural behavior of Sisal next to the Jute. It is because the addition of Sisal fiber significantly had the compatibility with the matrix phase, in addition to the lignite fly ash particulates. Other than Sisal, the agreement of compatibility of fiber and lignite fly ash is comparatively very low due to less absorption of flexural energy, de-bonding and load bearing ability of reinforcement phases for the provided load. In addition, the lignite fly ash bond seems very high due to its submicron scale and its uniform spherical shapes of particles. The resistance to the bending stress and good stress transfer is less in Sisal/LFA reinforced epoxy material than other kinds.

3.4 Characterization of Microstructure

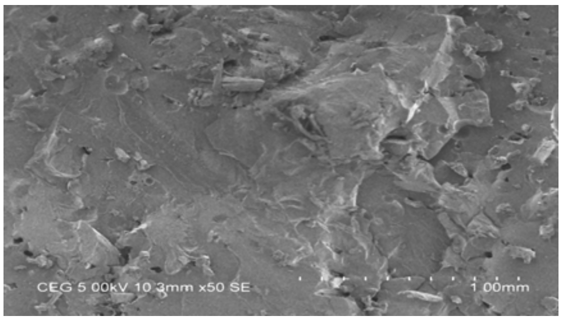

Fig.4 SEM images of Epoxy /Jute/LFA Sample after Tensile Test

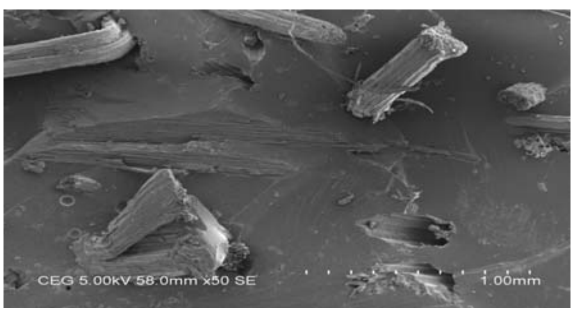

Fig.5 SEM images of Epoxy /Sisal/LFA Sample after Tensile Test

The characterization study was made on the cross section of the tensile tested samples and the structural studies were made using SEM analysis. The cross sectional view of broken side of tensile test specimens and it is shown in figure 4&5. For the Epoxy reinforced with 08% natural fibers Jute, Sisal respectively with the Lignite fly ash with the weight fraction of 2 %. It is observed that the dispersion of the LFA well homogenized in all the SEM micrographs. The Sisal witnessed higher dia than the jute and the fracture on increase tensile load that can be viewed by the out exploration of the fiber from the matrix phase, also it is seen that the LFA spread throughout and it is difficult to witnessed due to its very finer scale of 250 nm and it provide the sustainable hold to the fibres and reduce its displacement upon loading and helps to transfer the load stress to distribute to the LFA particles in matrix phase while tensile and flexural loading. The geo oxide element provides the significant toughness upon compressive loading so that good improvement is observed that shown in figure.2. It is due to the mechanical keying and chemical compatibility in between the matrix and two different reinforcements.

4. Conclusion

In this frame work an attempt was made to prepare the geopolymer composite of natural fibers (Sisal, Jute) and Lignite Fly Ash as reinforcements in the epoxy matrix phase. The Epoxy: Fibre: LFA were blended in the weight ratio of 90:08:02. The hand layup method was followed to prepare the proposed geopolymer composite material. The following observations were made;

i. The alkali treatment in the fibres made the significant strength effect and result in acting as a good reinforcement by deformation and stress transferring ability.

ii. The LFA addition witnessed homogeneous distribution in the matrix phase and the good mechanical and chemical compatibility were noticed in between fiber/LFA phase reinforcements in epoxy matrix. As a result the toughness is highly improved due to non movement of finer LFA particles.

iii. The bonding reaction in between the fibres and its orientation and LFA size, also its distribution helps in achieving higher order of anisotropic behavior for improvised properties like tensile, compression and flexural strength compared with pure epoxy resin.

References

1. Huda MS, Drzal LT, Mohanty AK, Misra M. The effect of silane treated- and untreated-talc on the mechanical and physico-mechanical properties

ofpoly(lactic acid)/newspaper fibers/talc hybrid composites. Compos: Part B 2007;38:367–79.

2. Whaling A, Bhardwaj R, Mohanty AK. Novel talc-filled biodegradable bacterial polyester composites. Ind Eng Chem Res 2006;45:7497–503.

3. Unal H, Mimaroglu A, Alkan M. Mechanical properties and morphology of nylon-6 hybrid composites. Polym Int 2004;53:56–60.

4. Huneault MA, Godfroy PG, Lafleur PG. Performance of talc ethylene–octane copolymer/polypropylene blends. Polym Eng Sci 1999;39(6):1130–8.

5. Ersoy OG, Nugay N. Effect of inorganic filler phase on mechanical and morphological properties of binary immiscible polymer blends. Polym Bull 2003;49:465–72.

6. Browning R, Lim GT, Moyse A, Sun L, Sue HJ. Effects of slip agent and talc surface-treatment on the scratch behavior of thermoplastic olefins. Polym Eng Sci 2006;6:601–8.

7. Dadkar a, Bharat S. Tomar Nandan b, Bhabani K. Satapathy . Evaluation of flyash-filled and aramid fibre reinforced hybrid polymer matrix composites (PMC) for friction braking applications

8. Richard J. Foster, Mark J. Bonner, Ian M. Ward . The use of nano and micron-sized particles to enhance the interlayer adhesion in self-reinforced, single-polymer composites