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A COMPARATIVE STUDY OF SISAL FIBER REINFORCED POLYESTER COMPOSITE

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Abstract

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. The developments of new materials are on the anvil and are growing day by day. Natural fiber composites such as sisal polymer composite becomes more attractive due to their high specific strength . light weight and biodegradability . Natural fiber seems to be a good alternative since they are abundantly available and agave sisalina can be used in this regard. In this work a comparative study of mechanical properties of sisal fiber reinforced composite is carried out with the glass fiber reinforced polymer composite. For this purpose composite beams of both the types with different volume fraction of fiber were prepared and tested. The tensile strength and impact strength was tested and compared accordingly.

Key words-Laminated beams, dynamic analysis, mode shape, symmetric orientation, finite element analysis, fiber orientation

Introduction

A composite is a structural material that consists of two or more constituents that are combined at a macroscopic level which are insoluble in each other and differ in form or chemical compositions. There are two phases of composite exists namely, reinforcing phase and matrix phase. The reinforcing phase material may be in the form of fibres, particles or flakes and the matrix phase materials are generally continuous such as polymer, metal, ceramic and carbon. The properties of the composite material largely depend on the properties of the constituents, geometry and distribution of the phases. Now a days a trend in the new material development has been focused to synthesize natural fiber reinforced composites as a replacement and substitute of conventional composite material. In this regard sisal fiber composite is found to be best suited for the purpose.

Current research shows that natural fiber reinforced composite industry will keep on growing quickly around the world with 10% [1]. Many researchers [2, 3, 4–6] have examined and researched the suitability, competitiveness, and capabilities of natural fibers embedded in polymeric matrices. The researchers [7, 8, 9] concentrated on the effect of the fiber surface modifications as well as manufacturing processes in improving fiber/polymer compatibility. Al-Oqla and Sapuan [10] investigated the properties of jute/plastic composites such as crystallinity, fiber modification, thermal stability, weathering resistance, durability, in addition to their suitability to the automotive industry throughout ecodesign components. while Mohanty et al. [11] studied the effects of jute fiber on the mechanical properties. NFPCs are such composites whose mechanical efficiency is dependent upon the interface provided by fiber-matrix along with the stress transfer function in which stress is transferred to fiber from matrix. This has been reported by many investigators in several researches [12, 13, 14]. Characteristic components of natural fibers such as orientation [15], moisture absorption [16], impurities [17], physical properties [18], and volume fraction [19] are such features that play a constitutive role in the determination of NFPCs mechanical properties. Along with High strength natural fiber reinforcement in polymers also provide extra or improved biodegradability, low cost, light weight, and enhanced properties related to mechanical structure [20]. At temperatures as high as 240∘ C, natural fibers start degrading whereas constituents of fiber, such as hemicelluloses, cellulose, lignin, and others, start degrading at different levels of temperature; for example, at 200∘ C lignin starts to decompose whereas at temperatures higher than this other constituents will also degrade [20]. Natural fibers have a short lifetime with minimum environmental damage upon degradation whereas synthetic ones affect environment due to pollution caused by degradation. Lignin, hemicelluloses, and cellulose concentrations or composition affect thermal degradation features of lingo-cellulosic materials [22]. More than fifty percent weight of jute or Biopol composite is lost after exactly 1500 days of burial [11].Over the last couple of decades, increasing numbers of car models, first in Europe encouraged by government legislation and then in North America, have featured natural fibre-reinforced polymers in door panels, package trays, hat racks, instruments panels, internal engine covers, sun visors, boot liners, oil/air filters progressing to more structurally demanding components such as seat backs and exterior underfloor panelling. Now, all of the main international automotive manufactures use these materials and their use is expected to increase in this area [23]. In India composite board has been developed as an alternative to medium density fibreboard which has been assessed for use in railcars [24]. The aircraft industry has also been adopting NFCs for interior panelling [25]. In sports, surfing appears to be of particular note with respect to embracing environmentally friendly materials. A number of companies are now advertising surfboards incorporating NFCs. One of the earliest was the ‘‘Ecoboard” produced by Laminations Ltd, using bio-based resin and hemp fibre [24]. A recent study supported the production of natural fibre surfboard fins through RTM to be possible regarding provision of mechanical performance and economic viability [26]. Fishing rods are also being produced using material developed by CelluComp Ltd who extract nanocellulose from root vegetables [27,24]. Recent research showing RTM flax reinforced polyester turbine blades to be a potential replacement for those reinforced with glass fibre obtained recognition by way of the Asia 2013 Innovation Award from the JEC composites group for the world’s first functional flax composite wind turbine blade [28]. Research has also shown the potential of NFCs for top-plates of string musical instruments [29].

From the above study it is evident that the importances of natural fiber reinforced composite materials are growing day by day to meet the needs of the society. Hence it is aimed to carry out the study on natural fiber. Sisal fiber is chosen after observing its availability in the locality and its superior properties over the natural fibers. To carry out the study, sisal fiber reinforced composite and E-glass reinforced polyester composite is prepared by hand layup process. The mechanical prosperities are tested and compared for both kinds of the materials for different volume fraction of the fiber content.

Preparation of the Mould

An open mould is used to prepare the beam specimen by hand lay-up process. The mould is prepared by commercial plywood covered by thin aluminum channels to obtain good surface finish of the product with cross-section 90×10×3cm. The surface of the mould is thoroughly cleaned to be ready for the use, by removing any dust and dirt from it.

After the mould surface has been cleaned, the release agent is applied. Where, the mould surface is coated with a mixture of soap and water layer by free hand. Before application of resin the coating is dried completely. This is very important as the surface of final article may be rough due to the presence of water particle.

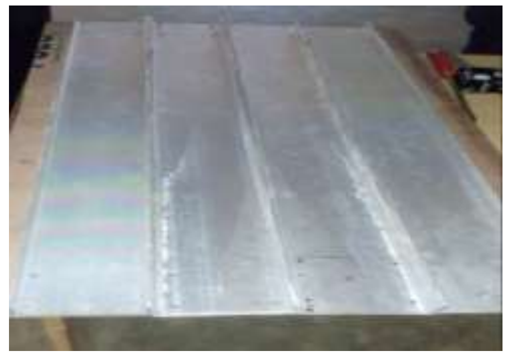

Figure2.1 Aluminum mould

Matrix Material

To prepare the beam specimen polyester is used as matrix or binder. Polyester can be defined as a long chain of synthetic polymers made from the combination of tetraphthalic acid (PTA) or dimethyl terephthalate (DMT) and monoethylene glycol(MEG). Chemically it comprises 85% of its total mass as easter and other 15% as dihydric alcohol and teraephthalic acid. In the current work polyester is used as matrix. The use of polyester have some sort of limitation such as, it may deform after heating and may be burn at high heat. However the use of polyester has also some sort of advantages like, it have high tenacity, young’s modulus and low water absorptive. It is cheaper and has easy market availability as compared to epoxy.
The polyester matrix is prepared by using General purpose (GP) Polyester resin; Cobalt Octate (0.35% by volume of resin) as accelerator, Methyl ethyl ketone peroxide (MEKP) (1% by volume) as catalyst. Resin, accelerator and catalyst are thoroughly mixed and left for some time so that bubbles formed during stirring may die out. The amount of added accelerator and catalyst is not high because a high percentage reduces gel time of polyester resin and may adversely affect impregnation.

Reinforcement

Reinforcement provides a base structure to the whole material. The reinforcement used may be particulate, whiskered, flaked or laminated. The fiber is used either may be continuous or Discontinuous. In this work continuous bi-directional woven fabric E-glass fiber & Natural Fiber (Sisal Fiber) is used as reinforcement.

Sisal Fiber

Sisal is a natural fiber (Scientific name is Agave sisalana) of Agavaceae (Agave) family yields a stiff fiber traditionally used in making twine and rope. Sisal is fully biodegradable and highly renewable resource of energy. Sisal fiber is exceptionally durable and a low maintenance with minimal wear and tear strength. Sisal fiber is produced by the way known as decortications, where leaves are compressed by a rotating wheel set with blunt knives, so that only fibers will remain. Sisal Fiber is exceptionally durable with a low maintenance with minimal wear & tear. Chemical composition of Sisal Fiber is Cellulose (65%), Hemi-Cellulose (12%), Lignin (9.9%) & Waxes (2%).

E-glass fiber

E-glass fiber contains alumino-borosilicate glass with less than 1% alkali oxides as its main constituent. The letter E is used as it was originally developed for electrical applications. The tensile strength of E- glass is comparatively less than S-glass. However it has higher tensile strength than that of c-glass fiber. Here E-glass fiber is used as reinforcement as it less costly than other varieties of glass fibers and the mechanical properties matches to the requirement.

Figure2.2 Sisal fiber and leaves

Preparation of the Test Specimens

The test specimen is prepared by wet layup process. During the preparation, the first layer of mat or fier is laid and resin is spread uniformly over the mat. After the second layer of mat is laid, to enhance wetting and impregnation, a teethed steel roller is used to roll over the fabric before applying resin to remove the trapped air bubbles and voids present in the resin. This process is repeated till all the fabric layers are placed. No external pressure is applied during casting or curing as uncured matrix material can squeeze out under high pressure. This causes surface waviness (non-uniform thickness) and roughness in the model material the casting is cured at room temperature for 24 hours and finally removed from the mould to get a fine finished plate.

Five test specimens with a volume fraction of fiber of 20%, 25%, 30%, 35% and 40% for both fiber glass and sisal are prepared.

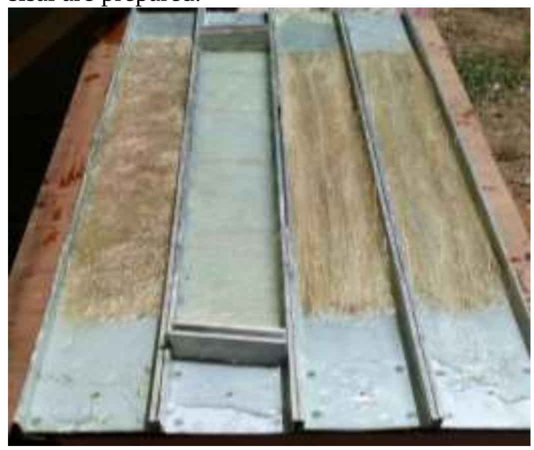

Fig. 2.3 Casted sisal fiber composite in the mould

After the curing process, test specimens are cut from the main sheets for UTM & Izod Testing. Natural Fiber (Sisal Fiber) & Glass Fiber of size 70 mm×10 mm by using a stone grinder. All the test specimens are finished by abrading the edges on a fine carborundum paper

Fig. 2.4 Test specimens for izod and tensile test

Tensile test of the specimen Using (UTM)

The tensile test for the specimens was conducted according to ASTM . The tensile test setup is shown in figure 3.1 . The specimens of size 250 mm x 25 mm x 10 mm were tested with a span length of 250 mm in tensile mode at a cross head speed of 1 mm / min. the sample test report of polyester glass and polyester sisal composite specimen with a volume fraction of (vm/vf=0.6:0.4)are given below in figure

Figure 3.1:- specimen Universal Testing Machine

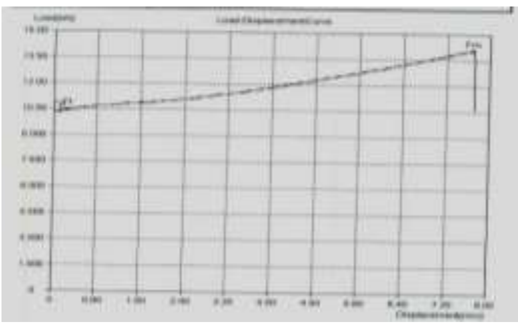

Figure 3.2 Displacement vs load curve for polyester-glass composite

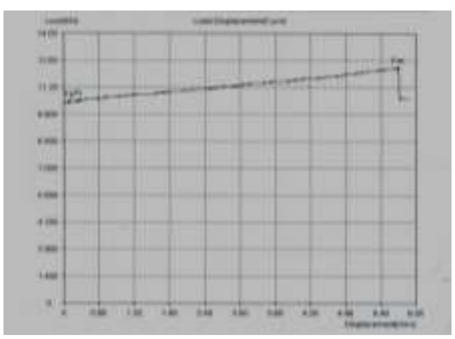

Figure 3.3 Displacement vs load curve for polyester-sisal composite

From the above graphs it can be seen that the test specimens bears a breaking load of 12.3KN and shows a deflection of 6mm for polyester sisal

Izod and charpy test

Impact test of composite was performed on the impact test machine .the setup of the test specimen in the test machine is shown in the figure 3.4 . the dimension of the the sample of 70×25×10 mm used for the impact test with notch thickness of 1 mm as per ASTM D 256. Five specimens of each composite were tested and average values are reported.

Fig 3.4: Impact testing setup

Table3.1. Mechanical properties of fiber glass and sisal composite

Sample no	Volume fraction of fiber in %	Tensile strength in MPa		Impact energy in J	
		Polyester-glass specimens	Polyester-sisal specimens	Polyester-glass specimens	Polyester-sisal specimen
1	20	65.2	56.1	134	93
2	25	78.3	72.35	141	135
3	30	89.23	85.25	172	149
4	35	115.2	98.23	192	184
5	40	157.4	135.23	228	198

Conclusion

From the study it has been found out that the tensile strength and impact energy of the composite material increase with increase in the percentage increase of volume fraction of the fiber content in the composite specimens. The conclusion is found to be valid both for sisal and glass fiber reinforced composite as depicted in figure4.1 and figure4.2. Also it has been found that though the tensile strength of sisal fiber composite is less than that of e-glass fiber reinforced composite, the strength is of up to the standard as depicted in table 3.1 and can be used in many uses as a replacement of the conventional glass fiber reinforced composite.

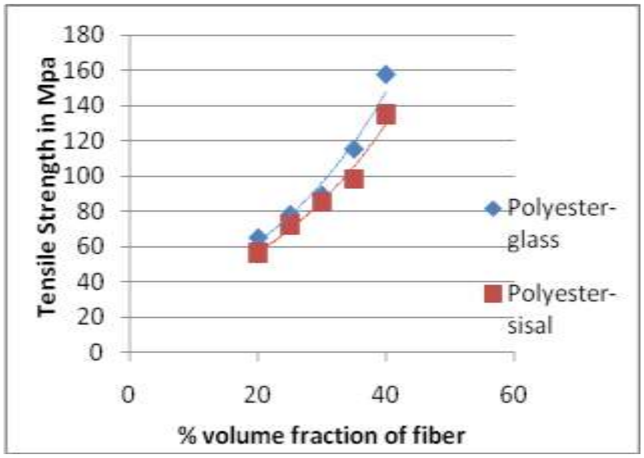

Figure 4.1 Variation of Tensile Strength With Volume fraction

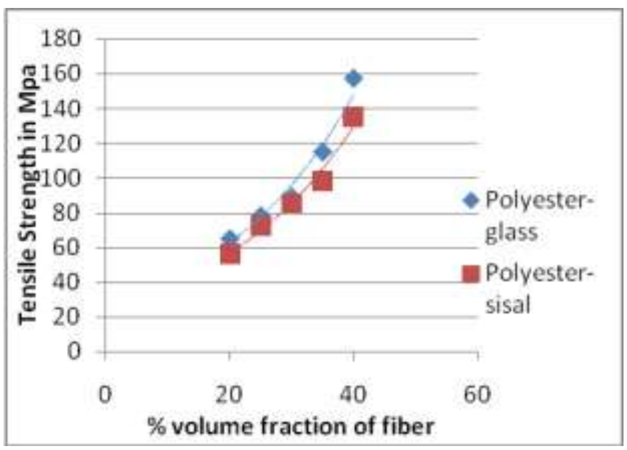

Figure 4.2 Variation of Impact Energy With Volume fraction

In the study the preparation of the composite specimen and study of mechanical properties of the natural fiber reinforced composite has been focused. The same can be used for the thermo-mechanical and dynamic analysis in the future both experimentally and numerically.

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