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A REVIEW ON NATURAL COMPOSITES

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Abstract

Natural fibers have attracted the interest to engineers, researchers, professionals and scientists all over the world as an alternative reinforcement, because of its superior properties such as high specific strength, low weight, low cost, fairly good mechanical properties, non abrasive, eco-friendly and bio-degradable characteristics. A brief review has been carried out to make use of the natural fibers (such as abaca, jute, cotton, coir, Glass fiber etc) abundantly available in India. This paper presents a review on the mechanical properties of Abaca, Jute, Glass fibre.

Keywords*:* Abaca,Jute,Cotton,Coir,Glass fiber, Natural fiber, Composite materials

1. INTRODUCTION

A composite is a combination of two materials in which one of the material, is called the reinforcing phase, which is in the form of fibers, sheets, or particles, and is embedded into other materials called the matrix phase[2]. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Composites typically have a fiber or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members[4] [12]. The matrix acts as a load transfer medium between the fibers, and in less ideal cases where the loads are complex, the matrix may even have to bear loads transverse to the fiber axis. The matrix is more ductile than the fibers and thus acts as a source of composite toughness. The matrix also serves to protect the fibers from environmental damage before, during and after composite processing. When designed properly, the new combined material exhibits better strength than each individual material. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications. "Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form" [1]. The composites should not be regarded simple as a combination of two materials. In the broader significance; the combination has its own distinctive properties. In terms of strength to resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them. "The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings", in order to obtain improved materials. Composite materials as heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be also considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property.

2. NATURAL COMPOSITE MATERIALS

Natural composite materials exist since first ancient builder used straw to reinforce mud bricks. In 12th century, Mongols made archery bow by using cattle tendons, horn, bamboo, silk, and natural pine resin. In late 1800s, canoe builders glued together layers of Kraft paper with shellac to get paper laminates. Though the concept was successful but performance of materials was not good. Between 1870 and 1890, a revolution took place with the development of first synthetic resin, called polyester by American Cyanamid and DuPont. During same period, Owens-Illinois began weaving glass fiber into a textile fabric on a commercialbasis.

From 1934 and 1936, Ray Green, combined these two new products for making small boats and this was the beginning of composite era. Composites industry began in late 1940s and expanded rapidly through 1950-55s. Boats, car bodies, truck parts, aircraft components, underground storage tanks, buildings are some of the products which were made at that time.

Composite material generally consists of two materials: one is the matrix and other is reinforcement, final product retains properties of each constituent. Wood is an example of natural composite material, made up of cellulose (reinforcement), and lignin (matrix). Other examples of natural composites are bones, teeth, plant leaves and bird feathers.

Some of the examples of natural composite materials are given below:

Wood: Wood is an excellent example of natural composite in which cellulose fibers are held together by lignin. Closely packed cellulose molecule provides higher density and strength in the composites. Presence of cellulose is responsible for adequate strength in plants and trees.

Bone and Teeth: Bone is a naturally occurring composite material made of calcium phosphate (mineral) embedded in collagen (protein) matrix, recent attempts to grow artificial hydroxylapatite bone composite have proved successful.

Bones contains short and soft collagen fibers i.e. inorganic calcium carbonate fibres dispersed in a mineral matrix called apatite. These fibers grow and get oriented in the direction of load. Tooth is a special type of bone consisting of flexible core and hard enamel surface, outer enamel have high compressive strength. Tooth has piezoelectric properties i.e. reinforcing cells are formed when pressure is applied.

Onkar V. Potadar *et.al* author was concerned with the preparation and testing of composite materials from groundnut shell fibres and coir fibres along with binder and epoxy resins. The groundnut shells are chemically washed, cleaned and then dried in sunlight. The dried shells are then grinded to particle sizes of 1 mm, 1.5 mm, 2 mm and the epoxy resins are added in 70:30 ratio by weight to the fibres in a 12 mm thick mould and different flat square-shaped composites are obtained. Specimens of different particle sizes are cut into standard dimensions as per ASTM for different mechanical and moisture absorption tests. The results thus obtained are relatively compared between groundnut shell and coir fiber composites so as to suggest suitable applications. In general, the coir fibre composites are found to be comparatively better than groundnut fibre composites particularly considering the mechanical properties. The highest tensile strength was found for a particulate grain size of 1 mm for both, groundnut fibre composites as well as coir fibre composites; however coir fibre composites had comparatively higher tensile strength than groundnut fibre composites. When it comes to higher flexural strength, again the particulate grain size of 1 mm provided the same for both, groundnut fibre composites as well as coir fibre composites; also coir fibre composites had comparatively flexural tensile strength than groundnut fibre composites. Overall, coir fibre composites are comparatively better than groundnut fibre composites as far as mechanical properties are concerned.

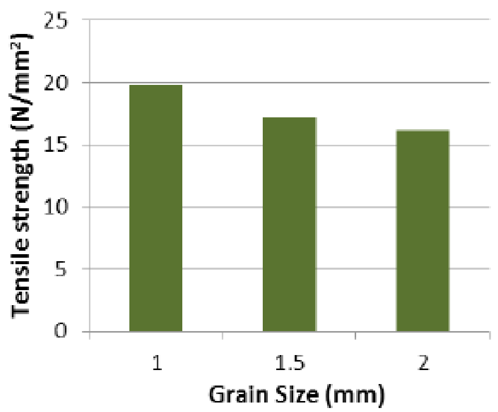

Figure: 1 Tensile strength based upon grain size

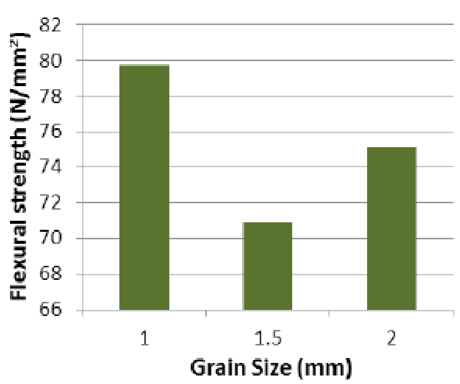

Figure: 2 Flexural strength based upon grain size

Panneerdhass studied the tensile, compressive, flexural, impact energy and water absorption characteristics of the luffa fiber and Groundnut reinforced epoxy polymer hybrid composites. Luffa fiber and Groundnut reinforced epoxy resin matrix composites have been developed by hand lay-up technique with luffa fiber treated conditions and Ground nut with different volume fraction of fibers as in 1:1 ratio (10%, 20%, 30%, 40% and 50%). Effects of volume fraction on the Tensile, Compressive, Flexural, Impact strength were studied.SEM analysis on the composite materials was performed. Tensile strength varies from 10.35MPa to 19.31MPa,compressive strength varies from 26.66MPa to 52.22MPa,flexural strength varies from 35.75 MPa to 58.95 MPa and impact energy varies from 0.6 Joules to 1.3 Joules, as a function of fiber volume fraction. The optimum mechanical properties were obtained at 40% of fiber volume fraction of treated fiber composites. Fractures surface of the composite shows the pull out and de-bonding of fiber is occurred.

Venkateshwaran studied on the tensile, flexural, impact and water absorption tests were carried out using banana/epoxy composite material. Initially, optimum fiber length and weight percentage were determined. To improve the mechanical properties, banana fiber was hybridised with sisal fiber and study to addition of sisal fiber in banana/epoxy composites of upto 50% by weight results in increasing the mechanical properties and decreasing the moisture absorption property. Morphological analysis was carried out to observe fracture behavior and fiber pull-out of the samples using scanning electron microscope. the mechanical properties also increases up to certain limit. Further, addition causes them to decrease due to poor interfacial bonding between fiber and matrix. The maximum mechanical properties, tensile strength, flexural strength and impact strength are found out as 16.39 MPa, 57.53 MPa and 13.25 kJ/m^2 respectively. These mechanical properties are for the fiber length of 5mm,15mm and 15mm respectively and the weight percentages of 12, 16 and16. the maximum tensile properties provided by 5 mm fiber length and 12% weight percentage is equivalent to the tensile properties of

15 mm fiber length and16% weight. Hence, we can choose 15 mm fiber length and 16% weight as the fiber length and weight percentage which pro- vide mechanical properties. The mechanical properties for this length and weight percentage are 16.12 MPa of tensilestrength,57.53 MPa of flexural strength and 13.25 kJ/m^2 of impact strength.

Based upon G.K. Sathiya research, the tensile strength and modulus of short, randomly oriented hybrid-natural fiber composite was found out experimentally and also predicted using Rule of Hybrid Mixture (RoHM). Hybrid composites were prepared using banana/sisal fibers of 40:0, 30:10, 20:20, 10:30, and 0:40 ratios, while overall fiber vol- ume fraction was fixed as $0.4V_f$. The comparison between experimental and RoHM showed that theyare in good agreement. the maximum tensile modulus of the composite along longitudinal and transverse direction are 0.385 GPa and0.371 GPa respectively for 50:50 ratio. Increment in modulus value is about 50% longitudinally and 15% transversely. Figs. 4 and 5 provide the information about the comparison of tensile properties between experimental and Rule of Hybrid Mixture (RoHM). As the individual properties of the fiber are used to predict the tensile properties of composite, RoHM also follow the same trend as the experimental properties. From those two figures we can say, the properties predicted using RoHM is closer with the experimental values but on the upper bound.

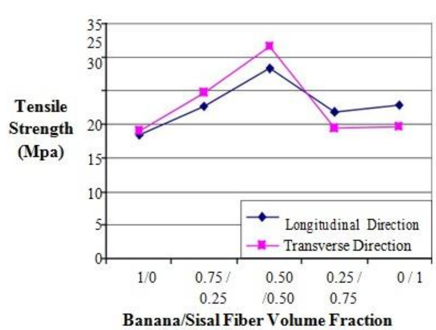

Figure: 3 Experimental tensile strength of hybrid composite.

Bledzki AK & Gassan J. (1999) developed an informative guide on resistance of thermoset piping materials to chemical attack. It is divided into two main sections: (1) a discussion of chemical resistance and general Considerations for end use applications and (2) a listing of chemical resistance data (table) for several thermoset piping materials applicable to non-pressure applications. Determination of suitability for specific applications under stress (pressurized service) is beyond the scope of this report.

Lucas, E.F., et al., (2009) investigated Composite materials in the oil industry have found their application in fabrication of secondary constructions, such as: floor grates, footpaths of platforms, Staircase railings etc. In housing modules of platforms, those materials find their application in manufacture of tanks, pipelines, and walls, refractory coats etc. For example, on the "Amoco Davy" platform at the North Sea about 16 t composite 1 University of Belgrade, Faculty of Mining and Geology materials are used for those purposes (Composites for the Offshore Oil and Gas Industry,

Williams G.I. & Wool R.P.(2012) work deals with fabrication and investigation of mechanical properties of natural fibers such as abaca and banana fiber and compares with the hybrid natural fiber composite. Tensile, flexural and impact strength of the composites are investigated in the process of mechanical characterization. The Reinforcement material used is a by-product of epoxy resin namely Bisphenol-A . Hand lay-up technique is used to manufacture the composite and the fiber content is varied

Rodriguez E.S., Stefani P.M. & Vazquez A. (2007) studied the effects of Fibers ‘Alkali Treatment on the Resin pipe line Processing and Mechanical Properties of Jute-Vinyl ester Composites, Journal of Composite Materials through volume fraction of up to 0.5. Glass fiber on top and bottom layers of the laminate improves it’s surface finish and adds up strength. The Natural fiber is sandwiched in intermediate layers with the glass fiber. It is found that Abaca-Glass composite is found to have better tensile strength than the other two combinations and Abaca-Glass-Banana Hybrid Composite is found to have better Flexural strength and Impact value.

Montestruc, A.N., M.A. Stubblefield, S.S. Pang, V.A. Cundy, and R.H. Lea(2007). analyzed Smoke and Toxicity Tests of Fiberglass- Resin Composite Pipe Samples. Composites, oil and gas exploration and production steadily declined, forcing a significant increase in U.S. imports of crude oil. the United States imported more than 50 percent of the nation's total demand, .To economically develop U.S. oil production in deep-water locations, the industry needed strong, lightweight materials to replace the heavy alloy traditionally used in oil platforms in seawater. If alloy pipe could be replaced with lightweight advanced composites, for example, benefits would include reduced weight on the platform deck, reduced cost of the piping, and reduced maintenance costs.

3. CONCLUSION

The mechanical and physical properties of natural fibers varies from fiber to fiber. Natural composites like abaca, sisal, Borassuss and Groundnut are used in many engineering applications, because of its superior properties such as specific strength, low weight, low cost, fairly good mechanical properties

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