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Development and Testing of a Basic and Hybrid Thermoset Composite Reinforced with Molluca Nut Powder, E-Glass Fibre and Carbon Nano Fibre

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Abstract – Molluca Nut shell powder and E-glass fibre of grade 300 with 5wt % and 15wt % were incorporated into an epoxy resin named Bisphenol A. Tensile and flexural tests were performed for studying the mechanical behaviour of the composites. The tensile and flexural strength of Molluca nut shell powder reinforced composite was found to be increased by 22% and 41% and that of E-glass fibre reinforced composite was found to be increased by 36% and 82% compared to neat epoxy. Hybridization of E-glass fibre(15 wt%) and Carbon Nano Fibre (0.75 wt%) was also incorporated into an epoxy resin. Tensile and flexural strength was found to be increased by 40% and 102.8% compared to neat epoxy.

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INTRODUCTION

Composite materials are known to mankind several years ago and these materials are applied to improve the quality of life. Composite materials result from an examination and advancement from past few decades. Composites have advanced from glass fiber for car body parts to particulate composites for aviation and to extent different applications. [1]

Polymer matrix composites are usually produced using epoxy resins because of its good mechanical properties. There are several techniques which are being used to improve its mechanical properties and one of them is reinforcing of composites. The main aim of this work is to study mechanical behaviour of natural and nano reinforcements combined with epoxy matrix Bisphenol A. [2]

In this work three reinforcements namely Molluca nut shell powder, E-glass fibre and Carbon nanofibers(CNF)were incorporated into epoxy named Bisphenol A. Epoxy resin was selected as a matrix because itis a desirable resin in the composite industry due to its good stiffness, strength,chemical resistance as well as dimensional stability. Hybridization was also done by mixing E-glass fibre and CNF.

II. EXPERIMENTAL

2.1 MATERIALS AND METHOD

Bisphenol A supplied by “Naptha Chemicals Bengaluru”. This is commonly abbreviated as DGEBA. This resin is cured at room temperatures with the help of hardners.

Molluca Nut shell powder was used as natural reinforcement (Scientific Name is Caesalpinia Cristae). Naturally available Molluca Nuts were collected and chopped using hammer.The chopped material was ground in electric grinder to obtain powder form.The powder obtained was wet and was allowed to dry in sunlight for 48 hours.

E-glass fibre was used as synthetic reinforcement. In E-glass fibre ‘E’ stands for initial electrical application. E-glass fibres, is mainly comprised of aluminium borosilicate which gives maximum tensile strength and flexural strength and this was chosen as synthetic material. This material is available cheaply in the market. Woven Mat of 500gms was purchased and was later cut according to the mould size. This material is usually available in form of mat fibre. This is added with epoxy in weight percentage layer by layer and then is made according to mould size which is selected by previous journal papers. Glass fibre is having a very good adhesive property.

Carbon Nanofibres(CNF) are cylindrical nano materials which are layered with graphene and are arranged as stacked plates, cups or cones.

Fabrication of composite was done using hand lay-up method for natural, synthetic and nano reinforcements.

Fig.1: Aluminium Mould

Mould was prepared using aluminium sheets (Fig. 1). Aluminium was selected as mould material since matrix material doesn't adhere with themould and removal of slabs is easy. Also during the curing of composites, heat is generated since it is an exothermic reaction and aluminium dissipates the heat generated. Mould was designed to accommodate three tensile test specimens and three bending test specimens of size as per ASTM standards.

Weighed proportion of resin was taken in a beaker and hardeners in the ratio 1:1:1.7 (1ml of accelerator, 1ml of promoter and 1.7ml of accelerator) were added. The resin with hardners was stirred using an electric blender to obtain uniform mixing. The mixture was then kept aside for 10 minsto allow the bubbles to settle down. Silicon release spray was used to fascilitate easy removal of the cast composite slab from the mould. Mould was placed on flat surface and the flatness was checked using spirit level. The mixture was then poured in the mould uniformly. After pouring rolling was done using a roller to remove entrapped air and bubbles.This mould was allowed to cure for 24 hours at room temperature. This process was followed to obtain the composites with molucca nut shell powder, E-glass fibre and CNF as reinforcements.

Three slabs were prepared and the combinations of slabs with their reinforcements were

1) Neat epoxy

2) 5wt% of molluca nut powder and 95wt% epoxy.

3) 15wt% of E-glass fibreand 85wt% epoxy.

4) Hybrid composite Type 1- 5wt% of molluca nut powder + 0.75wt% of CNF with 94.25wt% of epoxy.

Fig. 2 : Composite Slab

Prepared composite slabs were removed from moulds carefully to avoid damage during ejection. Markings were made on slab for tensile specimen and bending specimen according to ASTM standards. Slabs were then taken for cutting. Cutting was done using electrically operated hand held cutter (Fig. 3) at " KLS Gogte Institute of Technology Belagavi".

Fig.3 : Hand held cutter

2.2 MECHANICAL TESTING

Tensile and Flexural tests were performed using Universal Testing Machine(UTM) available at "KLS Gogte Institute of Technology Belagavi". The UTM has a maximum loading capacity of 40tons. For tensile testing of specimens ASTM Standard of D3039/D3039M was used. Tabbing was done at both ends of the specimen with 45^{o} angled groovesto ensure proper grip in the jaws of UTM. Fig.4shows tabbing on tensile test specimens.

For tensile tests, three specimens were tested and the average of the three was considered. Tensile strength and Young's modulus were calculated using formula.

$$\sigma = \frac{P}{A} \quad \text{.....(1)}$$

$$E = \sigma/\varepsilon \quad \text{.....(2)}$$

here $'\sigma'$ is tensile stress, P is load applied, A is cross sectional area, ε is the strain. Elongation and load at fracturewasrecorded in UTM.

Fig.4 : Tensile Specimen with tabbings at the end

For Bending Test ASTM Standard D790-02 was used. Three point bending test was carried out using

UTM machine. The specimen was keptonsupports with distance between supports i.e. the span length to depth in the ratio of 16:1and loaded gradually. Load was applied at the centre of the span length.

Load was noted from UTM machine and deflection was also recorded. The bending strength and bending modulus were calculated using formulae

BS = 3Fl/2b ……3.3

BM = $3Fl^3$ /$4bh^3d$……3.4

Fig.5 : Specimen loaded for bending test

Where BS-bending strength, BM-bending modulus, F-load in kN, l-span length, b-breadth, h-thickness, BM-bending modulus, d-deflection.

III. RESULTS AND DISCUSSIONS

3.1 TENSILE AND COMPRESSIVE TESTING

Tensile strength, bending strength and Youngs modulus of neat epoxy and compositesis tabulated as shown in Table 1.

Table 1: Tensile Test Results

SL No	Type of Composite	Tensile Strength (MPa)	Bending Strength (MPa)
1	Neat Epoxy	116.78	74.184
2	Molluca Nut Shell Powder	142.61	105.72
3	E-glass Fibre	159.24	135.39
4	CNF + E-glass Fibre	163.79	150.36

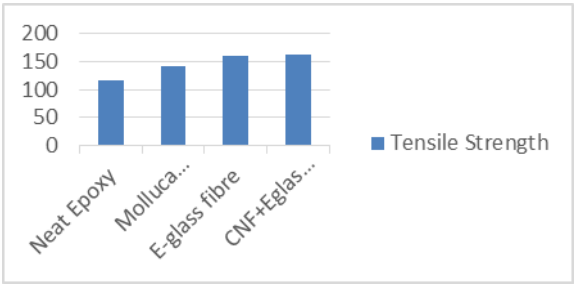

Fig. 6 : Tensile Strength

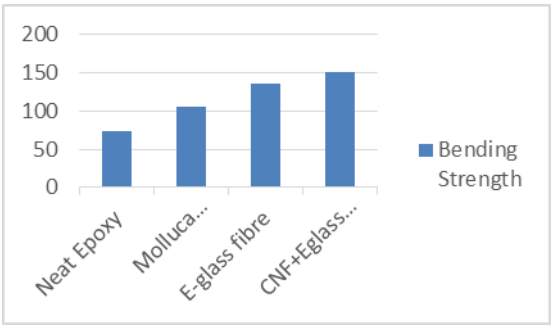

Fig.7 : Flexural Strength

Role of Molluca nut powder in tensile strength and bending strength.

From Fig. 6 it was seen that there is an impiovement in tensile properties of the composite. The tensile strength for Molucca nut shell powder reinforced composite was 142Mpa which exhibits a rise of 22.15% compared to neat epoxy. The powder reinforcement disperses well with the epoxy, providing localized reinforcement. However in flexural test, from fig. 7 it was observed that there was a nominal increase in flexural properties compared to neat epoxy. Obtained flexural strength was 105.72 Mpa exhibiting a rise of 42%.

Role of E-glass fibre in tensile strength and compressive strength.

E- glass fibre is a very good synthetic material and whenever it is reinforced with neat epoxy the result obtained are well. Fibre layers adhere well with the matrix and since glass fibre is in the form of a woven mat, the tensile strength will be more when compared with the neat epoxy and molluca nut powder. Tensile strength obtained was 159.24MPa that means the tensile strength was increased by 36.36%.By results we see that flexural strength obtained was 135.39 MPa and that means there was an increase 82.50% strength when compared to neat epoxy and bending strength shows an improvement when compared to both neat epoxy and natural reinforcement. Glass fibre is in woven mat form and fibres are arranged in all direction and hence flexural strength improves.

Role of Hybrid reinforcement in tensile strength and bending strength.

E- glass is synthetic reinforcement and when it is mixed with nano material and epoxy good results are obtained i,e 163.79MPa since the glass fibre is in woven mat form, fibres are arranged in each and every direction and loading is also uniform and hence it has got good adhesion capacity with epoxy and nano material also disperses well the epoxy and hence whenever these two are combined an increase of 40% strength is noted.Obtained flexural strength was 150.36MPa whenever these two reinforcements were combined an increase of 102.68% strength was noted.

IV. CONCLUSIONS

Tensile strength was increased by 22% and flexural strength was increased by 42% for molluca nut shell powder reinforced composite. The use natural reinforcement has many advantages like it is freely available, biodegradable, light in weight etc.

Synthetic Reinforcement used was E-glass fiber and using this material, tensile strength increased by 36%, bending strength increased by 82%. The strength was increased because glass fiber is in oven mat form and the orientations of fibers are multidirectional.

Hybridization of composites was also done in order to compare with natural and synthetic reinforcement. However by using CNF and E-glass fibre tensile strength was increased by 40% and flexural strength increased was 102%. Glass fibre is oven mat form and it adheres well with the reinforcement and even the fibres are oriented in all the direction and CNF provides nanometric dispersion strengthening.

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