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Development and Investigation of the Mechanical Behaviour of Okra, Coconut Coir, Cow dung and Sheep Hair Fibre Reinforced Epoxy Composites

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Abstract*—The invention and subsequent growth of composite materials has brought a revolution in the world over the last three decades. There has been a tremendous research these days because of their high strength to weight ratio especially in structural applications. The main theme of the current work is to develop a hybrid composite material based of Okra powder, Coconut Coir Fibres, Cow dung powder, and Sheep Hair Fibres in the ratios of 5%,10%,15%,20% with a fibre weight percentage (W_f)is kept constant at 0.3 for all the configurations. Coir and Sheep Hair are used as fibre reinforcement and Okra and cow dung powder as fillers with the stated configurations and the rest with matrix formed with LY556 Epoxy resin and HY951 Hardener andthe formed composites are cut into ASTM standardsand are tested for their Mechanical Properties, which as Tensile, Compression,Izod and Brinell's Hardness and their results are used to investigate their properties.

***Keywords*— Okra,Cow dung powder, Coconut coir, Sheep Hair, Hand Layup,Epoxy, Composites.**

I. INTRODUCTION

Composite materials in general consists of distinct and separate materials which have their own individual properties yet on combining them the formed new material shows a unique property.We can describe a composite as 'a multi-phased material from a mix of materials, varied in synthesis or form, which continue to be fortified together, however hold their personalities and properties, without going into any substance responses.' The parts don't break down or totally combine.They keep up an interface between each other and show enhanced, particular or synergistic qualities that are not realistic by any of the first segments acting separately.Composites show improved mechanical properties than that of other combined materials. In most cases composites are less in weight hence their utilisation makes the overall components much lighter.

Composite materials maybe widely classified into natural and synthetic composite Materials but there are other depending factors based on which the calculation is done. Synthetic Composite materials are in general prepared by adding the constituents separately and physically combining them by using different techniques and either in random or oriented arrangement of Fibres. Two ingredients may be composed together in any of the following methods:

(i) Layered composition in which layers of ingredient materials are bonded to one another, and

(ii) Phase composition in which one ingredient is inserted into the other ingredient.

The phase that receives the insert in the phase composition is the continuous phase and is called matrix. The purpose of adding the insert is generally to advance the mechanical behaviour of the matrix or to make it cost-effective. If the addition is made for better mechanical Properties, then it is called as reinforcement but if it is made to make it less costly or to modify any other property then it is known as a filler.

II. MATERIAL

For this current work we are using Sheep hair and Coconut coir fibres, properly cut into the equal lengths and are chemically treated with NaOH and are made ready to use as reinforcement for the composite preparation, whereas Cow dung and Okra are used aspowder in particulate form with varying compositions into four different configurations mixed along with epoxy resin LY556 and hardener HY951 in the ratio 10 :1 respectively. These are shaped into a mould of dimensions250mm x 125 mm x 15mm (length x width x thickness) for the preparation of the composites and are cut into specimens according to ASTM standards for tensile, compressive, hardness and Impact (Izod) tests and their mechanical properties are investigated by the results obtained. Other items used are the releasing agent, safety gloves, weighing scale, roller.

III. MANUFACTURING METHOD

The Composite materials can be manufactured by using any of the following methods.

- Hand Lay-up Method.
- Automated Lay-up Method
- Spray Up Method
- Filament winding
- Pultrusion

But for the current work we are going to prepare the composite materials by using Hand lay-up Method.

Hand lay-up encompasses the cutting of the reinforcement material to size by using a variety of hand and power-operated devices. These sized pieces are then impregnated with wet network material and laid over a shape surface that has been covered with a discharge operator and after that ordinarily a sap gel-coat. The impregnated fortification material is then hand-moved to guarantee uniform circulation and to expel caught air. Greater fortification material is included until the required part thickness has been developed. Manual lay-up can likewise be performed utilizing pre- impregnated support material, called 'prepreg'. The utilization of prepreg material disposes of independent treatment of the support and epoxy and can enhance part quality by giving more predictable control of fortification and sap substance. Prepreg must be kept refrigerated preceding use, be that as it may, to avert untimely curing.

IV. PREPARATION OF MATERIALS

A. Preparation of Okra:

We collected large amount of Okra (the scientific name is Abelmoschus Esulentus) nearly 5 kgs from a local Seller. These collected contained inner and outer layers. In this work we are going to use complete okra gum, hence nothing is going to be wasted. The Okra is thoroughly washed to remove any adherent impurities. Then the okra is cut small pieces and then they are drenched in Weight percentage of 5% NaOH solution for 12 hours to remove the moisture content and to have more adhesion to the fibres. After which these are exposed to sunlight for 72 hrs for drying process. Then the Okra gum is completely dried out and it can be powdered.

Fig: 1 (a) Collected Okra Fig :1 (b) Cleaned and treated Okra Fig :1 (c) Okra made into fine powder

B. Preparation of Coconut Coir:

In this research work, we collected the dried coconut husks from the coconuts and then they are separated as husk and fibre by using the mechanical pounding and patiently each of the fibre strand are separated as the Fibre and the husk, then the fibre is thoroughly washed with water and then they are chemically treated with 5% NaOH Solution and then it is dried it in the presence of sunlight with 48 hrs, then after the long fibres and are selected and are made into fibres of uniform length are selected for the preparation of the composites.

Fig: 2(a) Coconut Husk Fig:2 (b) Coir separated by pounding Fig:2(c) treated and dried fibres

C. Preparation of Cow dung powder:

Cow dung obtained from neighbourhood sources and undesired elements are removed, and then it is treated with 5 % NaOH and dried up in the presence of sunlight for 72 hrs. The dried cow dung cakes are then powdered by using mechanical pounding with a hammer and then are sieved for fine powder and it is used as per the required ratios for the composites.

Fig:3(a) Dried cow dung Cakes Fig:3 (b) Cow dung pounded Fig: 3 (c) Collecting cow dung powder

D. Preparation of Sheep Hair:

By taking the Sheep Hair, which is thoroughly cleaned with water and is chemically treated with 5 Wt.% NAOH solution for 12 hours. Then the fibre is dried in presence of sunlight nearly by 48 hrs. In, this current research works we are taking only sheep Hair fibre and coconut coir are mixed with each other as reinforcement for the composites

Fig:4(a)Collected Sheep HairFig: 4 (b) Fibre in 5%NaOH SolutionFig:4(c) Dried Sheep Hair Fibres

V. PREPARATION OF SPECIMENS

The sample preparation of the composite is done by using varying weight percentages of ratios. we calculate the required weight percentage of fibres, from the ratios table and then we calculate the weights accurately and are measured using them with a digital scale. Percentages are taken based up on varying proportions and ratio of mixtures.

The weight percentages are converted into grams by taking the epoxy and hardener mix as 200 grams, and by keeping the weight fibre ratio of 0.3 constantly for all the specimens. In order to note the variation with the decreasing fibre content we are decreasing the amount of fibre reinforcement in specimen C.

Specimen	% wt. of Okra	% wt. of Coconut Coir	% wt. of Sheep Hair	% wt. of Cow dung powder
A	5	10	15	20
B	10	15	20	5
C	20	5	6	10
D	20	5	10	15

Table 1: Compositions in ratios

Specimen	wt. of Okra in gm.	wt. of Coconut Coir in gm.	wt. of Sheep Hair in gm.	wt. of dung powder in gm.
A	6	12	18	24
B	12	18	24	6
C	24	6	8	12
D	24	6	12	18

Table 2: Compositions in grams

The Fibres were arranged uniformly as per above ratiosas mentioned in the table and the composites were prepared with LY 556 and HY 951 as matrix in the ratio of 10:1 mixture in the fabricated mould of dimensions 250 mm x 125 mm x 15mm and the prepared composites are sized according to ASTM standards for testing of mechanical properties which as Tensile, Compressive, Impact, Hardness Tests.

VI. TESTING OF SPECIMENS

A. Tensile Testing of the specimens:

This test reveals the amount of energy absorbed by a material during fracture, which refers to the materials tensile strength. The tensile strength test for specimens of dimension 240 mm length and thickness of 25 mm was obtained by using Universal testing instrument is used in this test. The impact strength is calculated from the following relation

Tensile stress = Tensile force / area



Fig: 5(a) Tensile Specimens prepared Fig:5 (b) Tensile Testing on UTM Fig: 5(c) Specimens after Tensile Testing

B. Compression Testing of the specimens:

This test uncovers the measure of vitality consumed by a material amid break, which alludes to the materials pressure quality. The pressure quality test for samples of dimensions 50 mm X 50 mm was tested.

Compression stress = compression force / area

For compression strength, the testing is done by loading the specimen on a compression testing machine according to ASTM standards and the observations are noted in the table. The compression is done in the lateral direction compared to that of the tensile testing direction.

Fig 6: Specimen loaded in Compression Testing Machine

C. Hardness Testing of the specimens:

Hardness is the resistance of a material to plastic deformation usually by Indentation. The term also refers that to the resistance to Penetration, Indentation, Scratching, Abrasion, or Cutting. Indentation hardness is a number related to the area or to the depth of the impression made by an indenter of geometry under a known Static Loads of 60 kgs, 100 kgs, 150 kgs are applied.

Fig 7: Specimen Loaded for Brinells Hardness Test

D. Impact Testing of the specimens:

Impact test is a single point test that measures the resistance of the material to impact from a swinging pendulum. Impact is defined as the kinetic energy needed to induce fracture and continue the fracture until the specimen is failed. All the tests are carried according to ASTM standards using an impact tester. Four samples were tested at ambient conditions and the average of impact strength was calculated.

Fig 8: Specimen loaded for Impact Test

VII. CALCULATIONS

A. FOR TENSILE STRENGTH:

Specimen (Okra, Coconut Coir, cow dung powder, Sheep Hair)	Peak Load (KN)	Elongation (mm)
A	6	4
B	3	2
C	2	3
D	4	4

Table 3: Observations for Tensile Testing of Composites A, B, C, D

For Specimen A:

Cross Sectional Area of the Specimen $(A) = W \; x \; T$ = 26.24 x 10.05 = 263.71 mm^2

Tensile Stress = $\frac{\text{Tensile Force}}{\text{Cross Sectional Area}} = \frac{6000}{263.71} =$ 22.75 MPa

Strain due to Tensile Force = $\frac{\text{Change in Length}}{\text{Original Length}} = \frac{244-240}{240}$ = 0.017 mm

% of Elongation = $\frac{\text{Change in Length}}{\text{Original Length}} x \; 100 = = \frac{4}{240} x100$ = 1.67 %

Young's Modulus = = $\frac{\text{Stress}}{\text{Strain}} = = \frac{22.75}{0.017}$ = 1338.24 MPa

B. FOR COMPRESSIVE STRENGTH**:**

Specimen Compositions Okra, Coconut Coir, Cow dung and Sheep Hair Fibre Ratios	**Compression Force (KN)**
A	325
B	335
C	310
D	355

Table 4: Observations for Compressions Tests for Composites A, B, C, D

For Specimen 'A':

Cross sectional Area of the Specimen $(A) = w * t$ = 50 * 10.5 = 525 mm^2

Compression Force of the Specimen = 325 KN

Compression Stress = $\frac{\text{Compression Force}}{Area} = \frac{325*1000}{525}$ = 619.04 MPa

C. FOR IMPACT STRENGTH

For Specimen 'A':

Width of the specimen =10.9 mm

Thickness of the specimen = 8.9mm

Area of the specimen = 10.9 x 8.9 = 97 mm^2

Force Required for Tool to Hit the Specimen is = 6 joules

Specific Impact Power = 4/97 = 0.04 J/mm^2

D. FOR BRINELLS HARDNESS TEST:

Specimen	**Load(f)&dia.(d)**	**Load(f)&dia.(d)**	**Load(f)&dia.(d)**	**Mean**
	Trail- 1	**Trail- 2**	**Trail- 3**	
A	60 & 1.4	100 & 1.6	150 & 1.7	103.33 & 1.57
B	60 & 1.3	100 &1.7	150 & 1.8	103.33 & 1.6
C	60 & 1.5	100 &1.8	150 & 1.9	103.33 & 1.73
D	60 & 1.4	100 &1.6	150 & 1.8	103.33 & 1.63

Table 5: Observations for Brinell's Hardness Tests for Composites A, B, C, D.

Hardness of the specimen (BHN) = Load Applied / Spherical surface area

$$= \frac{2P}{\pi D(D-\sqrt{D^2-d^2})}$$

Indenter dia.used (D) = 5 mm,

For Specimen 'A':

Brinell Hardness Number (BHN) = $\frac{2P}{\pi D(D-\sqrt{D^2-d^2})}$

$$= \frac{2x103.33x9.81}{5\pi(5-\sqrt{5^2-(1.57)^2})} = 510.37$$

VIII. RESULTS

Specimen Ratios	Tensile Strength (N/mm^2)	Compression strength (N/mm^2)	Hardness strength (BHN)	Impact Energy absorbed (Joules)
A	22.75	619.04	510.37	4
B	11.37	638.09	490.90	6
C	7.58	590.47	417.92	3
D	15.17	617.19	472.50	8

Table 6: Results for Tensile, Compression, Hardness, Impact Tests

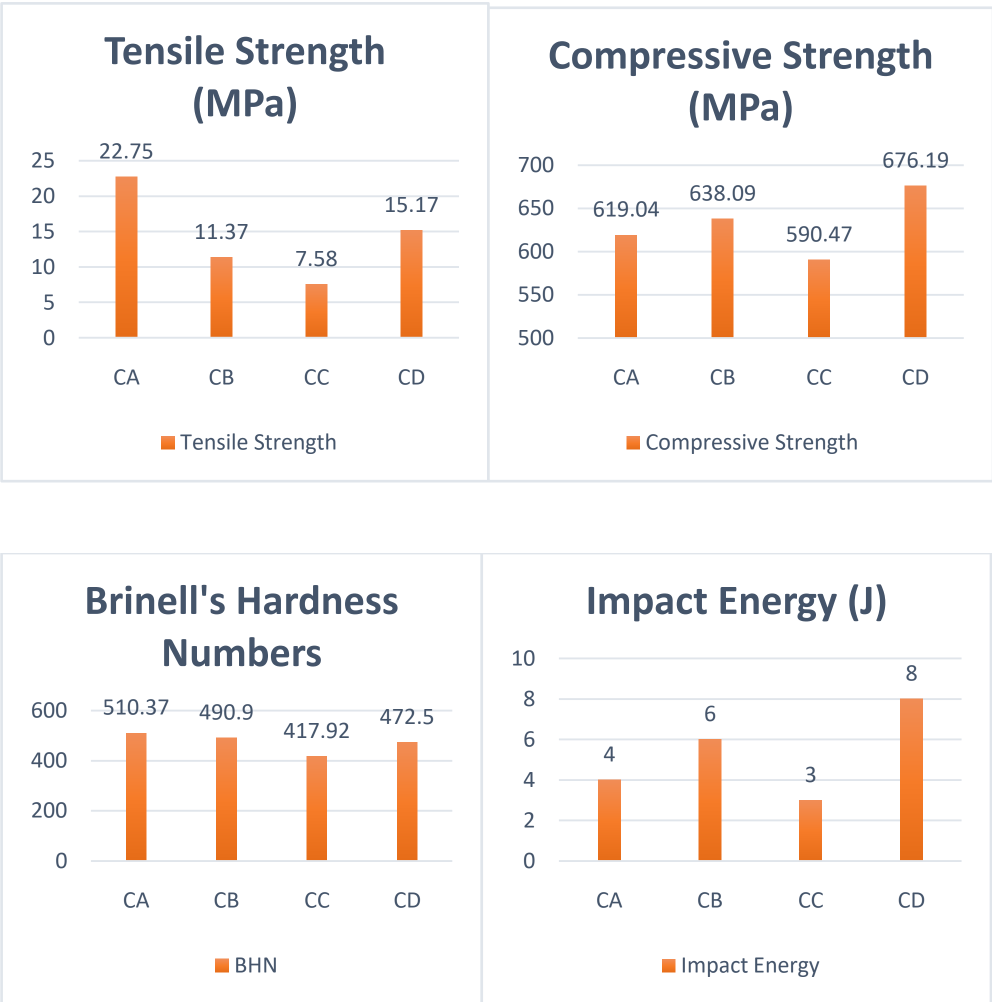

Fig 9: Graphs showing the variations among the prepared compositions for varying ratios

IX. CONCLUSIONS

- The Mechanical behaviour of the Composite Material has been estimated in the present work. The materials which are used in the synthesis of the current Composite had taken in different ratios are mixed with resin and hardener and made into rectangular slabs and are cut into ASTM standards and are tested experimentally for Tensile, Compression, Hardness and Impact tests.

- The Results found as High Tensile Test for CA composition, because of high cow dung (20%) gave good Tensile Strength and Strain and decreasing the Okra powder percentage (5%) because it acts as the Filler material as compare to the other Compositions like A, B and C to get higher values of tensile strength.
- For the composite "CD" ratio has good Compression Strength, because of high percentages of Okra, (20%) and Treated Cow dung Powder (15%) have good Compressive Properties and while increasing the percentages of Sheep Hair and Coir Fibres added up to the better performance in all of the tests. The Compression strength values increased from 590 MPa to 677 MPa as the testing is done in lateral direction of the specimens with the larger surface area.
- For Hardness and Impact Tests the Composite Material Contains High Hardness values increased from 417 to 510 Hb and Impact strength values increased from 3KJ to 8KJ.
- For the Specimen CC, we purposely reduced the fibre reinforcement and balanced the fibre weight percentage with the filler materials, and it proved very low compared to others which are well reinforced with the fibres, for all the test results of Tensile, Compression, Impact and Hardness tests, the values of the Specimen CC were low, so it is concluded that it fibre reinforcement has a Prominent role in the mechanical behaviour along with the fillers.
- So, from this Experiment we conclude that the Tensile and Compression Strength of Composite depended on the fibre weight percentage along the filler, Hardness on surface finish and impact energy on the density and the reinforcement in the synthesis of composites.

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