Investigation of Mechanical Properties in Polymer Based Composite Materials using Fish Scale and Chicken Feather Reinforcement

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Abstract— The renewable products are used for producing valuable and biologically sustainable material. It may reduce the waste and it also challenges the current research and development. In many of the researchers have focused their attention on natural fiber composite. The plant, mineral and animal fibers are called as natural fibers. In this project, we are using animal fibers like fish scales, chicken feathers and etc. The composites are developed by reinforcement of randomly oriented short flakes obtained from fish scales and chicken feathers into epoxy resin. The fabrication setup for composite materials has been developed by using hand layup technique. The fabricated composite specimen has been tested by means of tensile, compression, impact, hardness and water absorption test as per ASTM procedures. The composites have potential applications due to its behavior. It has structural applications and used as low cost housing materials.

Key words: Composites, Fish Scale, Chicken Feather, Epoxy Resin

I. Introduction

Composites are made up of individual materials referred to as constituent materials. There are two main categories of constituent materials: matrix (binder) and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. A synergism produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination.

Many commercially produced composites use a polymer matrix material often called a resin solution. There are many different polymers available depending upon the starting raw ingredients. There are several broad categories, each with numerous variations. The most common are known as polyester, vinyl ester, epoxy, phenolic, polyimide, polyamide, polypropylene, PEEK and others. The reinforcement materials are often fibers but also commonly ground minerals. The various methods described below have been developed to reduce the resin content of the final product, or the fiber content is increased. As a rule of thumb, lay up results in a product containing 60% resin and 40% fiber, whereas vacuum infusion gives a final product with 40% resin and 60% fiber.

The strength of the product is greatly dependent on this ratio. Composite materials are generally used for buildings, bridges and structures such as boat hulls, swimming pool panels, racing car bodies, shower stalls, bathtubs, storage tanks, imitation granite and cultured marble sinks and countertops. Concrete is the most common artificial.

Composite material of all and typically consists of loose stones (aggregate) held with a matrix of cement. Concrete is an inexpensive material, and will not compress or shatter even under quite a large compressive force. However, concrete cannot survive tensile loading (i.e., if stretched it will quickly break apart). Therefore, to give concrete the ability to resist being stretched, steel bars, which can resist high stretching forces, are often added to concrete to form concrete. Concrete is a mixture of cement and aggregate, giving a robust, strong material that is very widely used. Fiber (FRP) includes carbon-fiber-reinforced polymer (CFRP) and glass-reinforced plastic (GRP). If classified by matrix then there are thermoplastic composites, short fiber thermoplastics, long fiber thermoplastics or long fiber-reinforced thermoplastics. There are numerous thermosets composites, including paper composite panels. Many advanced thermoset polymer matrix systems usually incorporate aramid fiber and carbon fiber in an epoxy resin matrix.

The most of the fish skins are covered with scales. Scales are very large in structure, shape and size, extent, ranging from strong and rigid armor plates in fishes such as shrimp fishes and box fishes, to microscopic or absent in fishes such as eels and anglerfishes.

The shark’s fishes are covered with placoid scales. Many of the bony fishes are covered with the cycloid scales of salmon and carp scales of perch, sturgeons and gars. Fish scales are part of the fish's integumentary system, and are produced from the mesoderm layer of the dermis, which distinguishes them from reptile scales. Labeo rohita (common local name is Rohu) was chosen for present study as it is easily available. This is a typical fresh water fish and can be identified by the dark scales present on its upper body. It Rohu fish scale are used as a reinforcement.

Chicken Feather Fiber (CFF) is deliberated as an unwanted product from the poultry production. Large amount of waste feathers generated and disposed each year by the poultry processing plants results in severe solid waste trouble. Feathers are greatly ordered, hierarchical branched structures that are standing among the most complex of keratin structures establish in vertebrates. Down feathers are smaller than contour feathers and lack barbules and the accompanying hook lets. They are soft and fluffy, located beneath the contour feathers. They provide most of a chicken's insulation. There are several subcategories of down, including natal down, present only at hatching, and powder down, which is a specialized feather type that sheds a fine, white keratin powder. The waxy powder is composed of granules so small that it is unwettable and thus forms a waterproof barrier for contour feathers. The semi plume is a feather type that mediates between the categories of contour and down. The smallest type of feather is the bristle, which is stiff and has few, if any, short barbs near the tip. Bristles are protective in function and are found on a chicken's head, at the base of the beak, around the eyes, and covering the nostrils.

II. LITERATURE SURVEY

This chapter outlines some of the recent reports published in literature on composites with special emphasis on erosion wear behavior of glass fiber reinforced polymer composites. As a result of the increasing demand for environmentally friendly materials and the desire to reduce the cost of traditional fibers (i.e., carbon, glass and aramid) reinforced petroleum-based composites, new bio-based composites have been developed. Researchers have begun to focus attention on natural fiber composites (i.e., bio composites), which are composed of natural or synthetic resins, reinforced with natural fibers. Natural fiber exhibit many advantageous properties, they are a low-density material yielding relatively lightweight composites with high specific properties.

Alok Satapathy et al. (2009) [1] developed a composite by using short flakes of fish scales and embedded them into epoxy resin. A commonly found fresh water fish called Labeo rohita was considered for making the composite. The processing, characterization and erosion wear characteristics of the fabricated composites were studied. They concluded that these composites possess very low amount of porosity and improved micro-hardness. They exhibit slightly inferior tensile and flexural strengths than those of the neat polymer.

R. Chakraborty et al.(2010) [2] This explores the feasibility of converting waste Rohu fish (Labeo rohita) scale into a high-performance, reusable, low-cost heterogeneous catalyst for synthesis of biodiesel from soybean oil. Scanning Electron Microscopy (SEM) morphology studies of the calcined scale depicted a fibrous layer of porous structure. Fish (L. rohita) scale mainly consists of different organic matters, water and some amount of minerals (Pati et al., 2010). In the present study, the effect of calcinations temperature on weight loss offish (L. rohita) scale powder was revealed through TGA over the temperature range from 30 to 1000 _C. The present study demonstrates the successful application of calcined fish scale as an efficient heterogeneous catalyst for transesterification of soybean oil. Calcinations of fish (L. rohita) scale in air at moderately high temperatures (P900 _C) generated b-Ca3 (PO4)2; which could effectively catalyze the methanolysis of refined soybean oil to yield FAME (biodiesel). Higher biodiesel yield could be achieved at moderately lower catalyst concentration and alcohol to oil molar ratio.

T. Subramanian et al. (2014) [3] the purpose of the study is to utilize the chicken feather and finding the mechanical properties of the chicken feather reinforcing with polyester and phenyl ester. The poultry waste can be utilized and used in any engineering applications, and it will be preferred due to low-cost and superior characteristics and the most importantly it will not cause ecological and health problems. Here used as down feather. It smaller than contour feathers and lack barbules and the accompanying booklets. They are soft and fluffy. The composites were fabricated with different fiber loadings (10%, 20% and 30%), remaining percentage as a matrix with fabric a hand-lay-up technique. the reinforced composite better than at 5% level and the Tensile and flexural properties of composite are control with the resins Polyester having significantly superior properties to the 25% CFF reinforced composite

Animesh Borah et al. (2015) [4] develop a polymer based composite with fish scale reinforcement. Fish scales are converted into flakes and three pre-determined weight proportions (5, 10, 15 wt %) are considered for reinforcement. This amount of reinforcement used in the polymer composite. Design and fabrication of hand lay-up set up for fabrication of composites was done.

Gagan Bansal et al. (2016) [5] application and properties of chicken feather fiber (CFF) a livestock waste in composite material development. Chicken feathers contain 91% protein (keratin), 1% lipids, and 8% water (Fraser and Parry, 1996). It provides low cost output in high strength composite design application by mixing it with other reinforcing materials. Tensile tests on keratin from 8 species of birds belonging to different orders showed similar moduli (mean E=2.50 GPa) except grey heron (E=1.78 GPa). It was concluded that from the species studied, the Flexural Stiffness of the whole rachis is principally controlled by its cross-sectional morphology rather than by the materialistic properties of the keratin (Jang and Lin, 1989.various composition of chicken feather are randomly orientated into matrix.

III. METHODOLOGY

A. Preparation of Fish Scale

The collected fish scales are washed in water at two times to remove adhering dust and soluble surface impurities. The fish scales are allowed to dry in sunshine for 48 hours and then this fish scale are fry at crispy. The dried fish scales are arranged and cut into the small flakes with the help of hand. Then these fish scales are used as the reinforcing phase.

B. Preparation of Chicken Feather

The collected chicken feathers are washed at two times to remove the blood, faces, skin and other impurities. The chicken feathers are allowed to dry in sunshine for 24 hours. Dried feather are treated by sodium hydroxide [NaOH] with distilled water, 1 liter distilled water take a 6% of NaOH for make a solution. In this solution feathers are soaked for 3 hours then it allowed drying for 10 hours. Then these chicken feathers are used as the fiber of reinforcing phase.

C. Preparation of Mould

The die is prepared with Mild Steel. The size of the die is 300mm×150mm×8mm as shown in fig.1.

Fig. 1: Mould

D. *Composite Preparation*

The epoxy resin and reinforcement take as an 80%, 20% respectively. Epoxy resin (Araldite LY 556) and corresponding hardener (HY951) are mixed in a ratio of 10:1.5 by weight as recommended. Density of the epoxy resin system is 1.1 g/cc. In the 20% reinforcement fish scale and chicken feather composition are (15:5, 10:10 and 5:15 wt %) are reinforced with random orientation into the epoxy resin. The matrix and fiber are thoroughly mixed, it keeps block at size (300mm×150mm×8mm).The castings are apply a load for compression of mixer. Then it keeps on 24 hours for curing at room temperature. After 24 hours these material can be remove from the mould. Here producing composite materials are three different reinforcement amounts. This material machined at required shape and dimension of ASTM procedure for involve testing. The composite material is shown in fig.2.

Fig. 2: Composite Materials

IV. RESULT AND DISCUSSION

This chapter deals with the evaluation of the mechanical properties of fish scale and chicken feather reinforced composites. Result have been presented using on basis of volume of fraction with the mechanical properties are tensile strength, compression strength, impact strength hardness strength and % of water absorption were calculated. It can be seen that fish scale and chicken feather reinforced composite will have potential applications due to its improved the behavior, the mechanical properties can be enhanced with the increasing percentage of reinforcement with different matrix. Another way to enhance the composite properties is to determine an effective treatment to eliminate lack of adhesion between matrix and reinforcement.

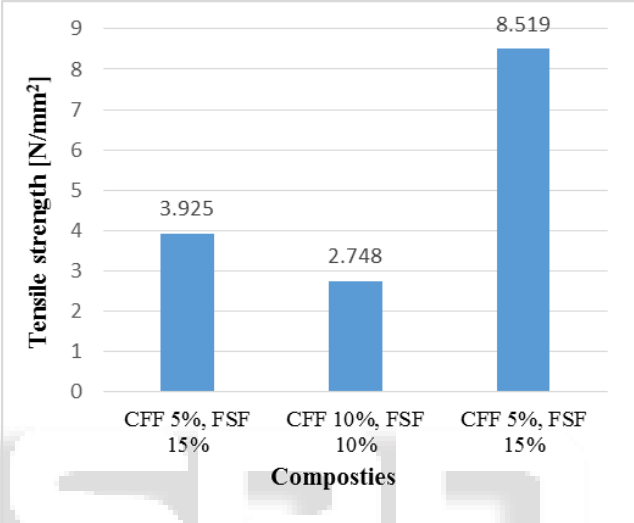
A. *Tensile Test Performance*

Tensile test is done on a dried specimen with a size of 210mm X 25mm X 5mm. The tensile specimen is straight sided and has a constant cross section with beveled tabs adhesively bonded from both ends. Here we using ASTM A370 standard for tensile test.

The details of Tensile Test of composite for varies percentage of fish scale and chicken feather with epoxy resin mixtures as follows:

Composites	Cross Sectional Area [mm^2]	Peak Load (in N)	% Elongation	UTS [N/mm^2]
CFF 5%, FSF 15% & Epoxy resin 80 %	122.29	480	2.48	3.925
CFF 10%, FSF 10% & Epoxy resin 80 %	116.43	320	0.62	2.748
CFF 5%, FSF 15% & Epoxy resin 80 %	131.50	1120	2.20	8.519

Table 4.1: Tensile Strength of Chicken Feather and Fish Scale Reinforced Composite



Graph 4.1: Effect of Fibers on Tensile Test

The graph 4.1 shows the relationship between the fabrication parameter, (different wt percentages of reinforcement and matrix and tensile strength in N/mm^2. Maximum tensile strength of 8.519 N/mm^2 was obtained in 15 wt % of chicken feather, 5 wt % of fish scale and 80 wt % of epoxy resin. The low value of the tensile strength of 2.748 N/mm^2 was obtained in 10 wt % of chicken feather, 10 wt % of fish scale and 80 wt % of epoxy resin. It was observed that the addition of chicken feather $^{\text{reinforcement}}$ in composite, having more tensile strength of polymer based composites.

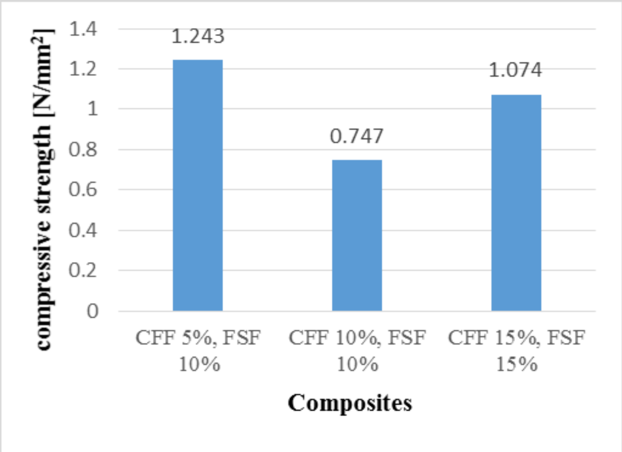
B. *Compression Test Performance*

This compression test is done by applying compression load to the specimen of size 90mm x 30mm x 3mm and this is also done by using the Universal Testing Machine. Here we ASTM A370 is used for testing. The details of compressive test of composite for varies percentage of fish scale and chicken feather with epoxy resin mixtures as follows:

Composites	Cross Sectional Area [mm^2]	Peak Load (in N)	Compression Strength [N/mm^2]
CFF 5%, FSF 15% & Epoxy resin 80 %	225.23	280	1.243
CFF 10%, FSF 10% & Epoxy resin 80 %	214.26	310	0.747

CFF 5%, FSF 15% & Epoxy resin 80 %	204.84	220	1.074

Table 4.2: Compression Strength of Chicken Feather and Fish Scale Reinforced Composites



Graph 4.2: Effect of Fibers on Compression Test

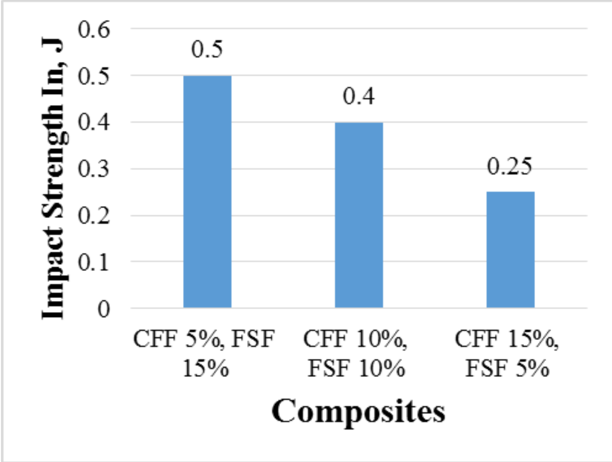
The graph 4.5 shows the relationship between the fabrication parameter, (different wt percentages of reinforcement and matrix) and compressive strength in N/mm2. The maximum compressive strength value 1.243 N/mm2 was observed in 5 wt % of chicken feather, 15 wt % of fish scale and 80 wt % of epoxy resin. The low value of the compressive strength of0.747N/mm2 was obtained in 10 wt % of chicken feather, 10 wt % of fish scale and 80 wt % of epoxy resin. It was observed that the addition of fish scale reinforcement in composite, having more compressive strength of polymer based composites.

C. *Impact Test Performance*

The impact test is for evaluating the toughness and notch sensitivity of engineering materials. Impact test is done in Charpy Impact test bed. The specimen for impact test is 65mm X 15mm X 3mm. The specimen is placed horizontally in the test bed. The pendulum is lifted and is made to hit the specimen from height. Each method particle absorbs energy when it is hit under some height. Here ISO 148-1is used for testing. The details of charpy impact test of composite for varies percentage of fish scale and chicken feather with epoxy resin mixtures as follows:

S.NO	COMPOSITES	IMPACT STRENGTH ,in [joules]
1	CFF 5%, FSF 15% & Epoxy resin 80 %	0.50
2	CFF 10%, FSF 10% & Epoxy resin 80 %	0.40
3	CFF 5%, FSF 15% & Epoxy resin 80 %	0.25

Table 4.3: Impact Strength of Chicken Feather and Fish Scale Reinforced Composites



Graph 4.3: Effect of Fibers on Impact Test

The impact strength of these composites is affected by the addition of the chicken feather. It was observed that the addition of fish scale reinforcement in composite, having more impact strength of polymer based composites

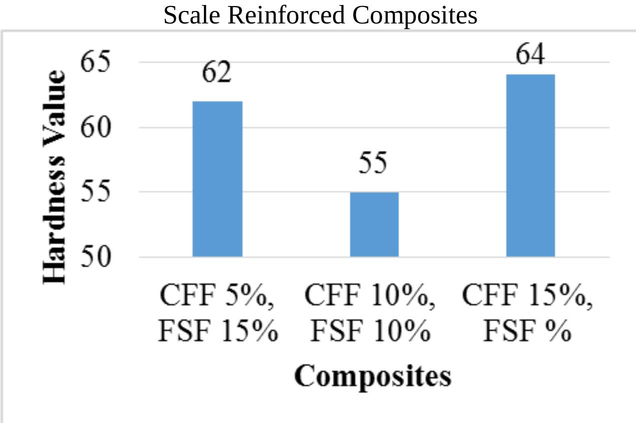
D. *Hardness Test Performance*

The hardness is defined as the material resistance to the indentation. This hardness test is for evaluating the material hardness. The hardness test was done by Shore-D. Here we using ASTM D2240 for testing. The specimen size for this hardness testing is 50mm X 50mm X 6mm.

The details of Tensile Test of composite for varies percentage of fish scale and chicken feather with epoxy resin mixtures as follows:

Composites	Observed value, 1	Observed value, 2	Observed value, 3	Average, SHORE -D
CFF 5%, FSF 15% & Epoxy resin 80 %	60	62	63	62
CFF 10%, FSF 10% & Epoxy resin 80 %	53	56	56	55
CFF 5%, FSF 15% & Epoxy resin 80 %	63	64	64	64

Table 4.4: Hardness Value of Chicken Feather and Fish Scale Reinforced Composites



Graph 4.4: Effect of Fibers on Hardness Test

The graph 4.4 shows the relationship between the fabrication parameter and hardness value. The maximum hardness value obtained in 15 wt % of chicken feather, 5 wt % of fish scale and 80 wt % of epoxy resin. The minimum hardness value obtained in 10 wt % of chicken feather, 10 wt % of fish scale and 80 wt % of epoxy resin. It was observed that the addition of chicken feather reinforcement in composite, having more hardness strength of polymer based composites.

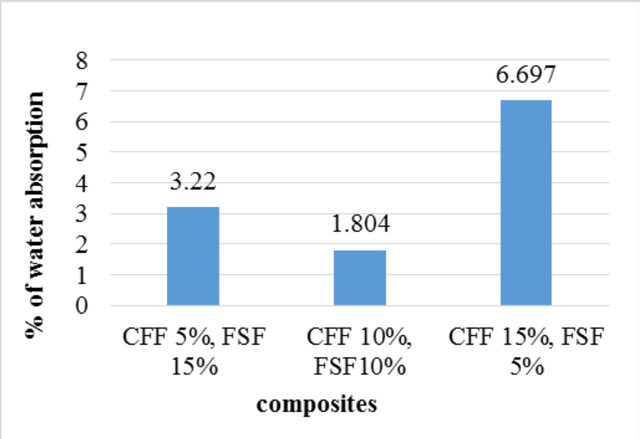
E. Water Absorption Test

Water absorption is used to determine the amount of water absorbed under specified conditions. Water absorption tests were carried out following the recommendations specified in ASTM D570 for the water absorption test.

The details of water absorption test of composite for varies percentage of fish scale and chicken feather with epoxy resin mixtures as follows:

Composites	Empty (g)	30 Mins (g)	60 Mins (g)	90 Mins (g)	% of water absorption
CFF 5%, FSF 15% & Epoxy resin 80 %	5.98	6.256	6.131	6.179	3.22
CFF 10%, FSF 10% & Epoxy resin 80 %	10.012	10.18	10.26	10.19	1.804
CFF 5%, FSF 15% & Epoxy resin 80 %	5.712	5.941	5.982	6.122	6.697

Table 4.5: Water Absorption of Chicken Feather and Fish Scale Reinforced Composites



Graph 4.5: Effect of Fibers on Water Absorption

The graph 4.5 shows the relationship between the fabrication parameter and % of water absorption. The minimum water uptake was absorbed in chicken feather 10%, Fish scale 10%, Epoxy resin 80% composite is 1.8045%, because of the presence of less amount of chicken feather i.e. increasing the water resistance. Whereas the addition chicken feather fiber is increasing the water absorption.

V. Conclusion

Through the review made here it can be concluded that the CFF and FSF has immense importance and great scope of improvement and discovery through advanced research in the field of advanced composite material. Natural bio-fiber based resin based fish scale and chicken feather reinforced composite materials were designed and fabricated with random orientations of the flakes by simple hand-layup technique. Different combinations can be made along with FSF and CFF as Matrix. This study opens up a new avenue for utilization of a bio-waste like fish scale and chicken feather. The fabricated composite materials are evaluated and fined out the mechanical properties (tensile strength, compression strength, impact strength, hardness, water absorption) followed by ASTM procedure. CFF had high percentage of composite material exhibited better values of tensile strength and hardness. FSF had high percentage of composite material exhibited better values of compressive and impact strength. Equal percentage of CFF and FSF composite material exhibited high water resistance. This composites can be used in low load application as per the design obtained through this project.

A. Scope for future work

- In future, the fabrication work is done by using other methods such as compression moulding, pultrusion method, hand lay method, twin screw extruder etc.,
- FSF can be used in the form of powder and it can be used to form composite material.
- By adding various compositions of eggshell powder with CFF and FSF, gives better mechanical and thermal properties in the future.

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