ANALYSIS OF PROPERTIES OF ARTIFICIAL BIOLOGICAL COMPOSITE MATERIALS

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Abstract- Market demands environmental friendly fibrous materials which enables composite materials to be manufactured. Composites have already proven their worth as weight saving materials; the current challenge is to make them cost effective. Natural fiber composites can easily be recycled than glass fiber or carbon fiber composites. The natural fibers are currently extracted from plants like sisal, jute, and palm etc….wood-thermoplastic composites products are growing rapidly. Major markets are decking materials, pallets, automobiles and building materials. Animals can also provide a source of fibers. The animal products like hair, bird's feathers, quills etc. can be used as fiber materials. It is anticipated that by incorporating quill particulates into polypropylene/epoxy resin matrix, the composite materials can be produced which can give good mechanical with low weight. Also the quill being the waste product of the poultry industry, the final cost of the composite product will be too low compared to other biological composite material. Meanwhile the problem of poultry solid waste handling can be solved.

Key Words: Biological composite, Hand Layup Technic, Fibers, slabs, testing, animal waste.

Introduction

It is truism that technological development depends on advances in the field of material. One does not have to be an expert to realize that the most advanced turbine/aircraftdesign is of no use if adequate material to bear the service loads and condition are not available

Since the early 1960 there has been an increasing demand for material that stiffer and stronger yet lighter in fields as diverse as aerospace, energy and civil construction. The demands made on materials for better overall performance are so greater and diverse that number one material can satisfy them. This leads to resurgence of the ancient concept of combining different materials in an integral –composite material to satisfy the user requirement

Yes composite material is an ancient concept or we can say it is a natural concept. In the nature we can get a no. of natural and artificial composite materials. For example coconut palm leaf,wood,bone, carbon black in rubber, Portland cement and glass fibers in resins etc.

In all above ex. We saw two phases in each that is a continues matrix phase and reinforced fibrous phase. This is because the reinforcement of flexible fibers in to the matrix gives high strength materials with lighter weight. In present day we are manufacturing composite materials by using glass fibers, carbon fiber, natural fibers and metallic fibers in resins, ceramics and other matrix materials.

The vegetable kingdom is the largest source of the natural fibers. Cellulosic fibers in the form of cotton, flax, jute, hemp, sisel and ramies have been used as fiber in manufacturing of composite material. Also the natural fibers from animal source such as wool,hair and silk can be used as fibers therefore the classification of the fibers can be given as follows

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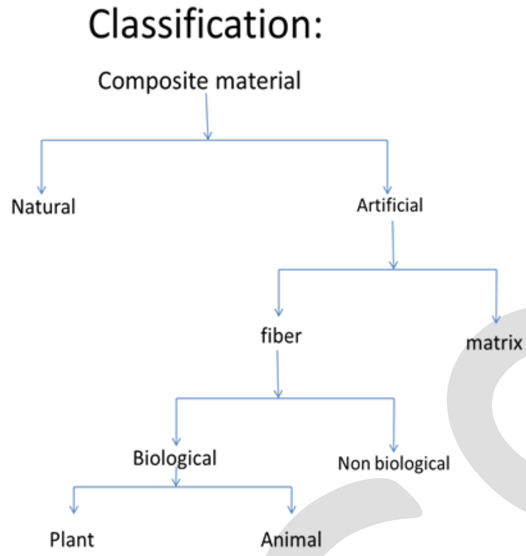


Another member to the animal based natural fiber is quill. The fiber obtained from the feather of the ground hen which consist rich amount of Keratin protein can be used as the fiber material for manufacturing composites.Chicken feathers are approximately 91% protein (keratin), 1% lipids, and 8% water.

Objective and Scope Of The Paper

1. To show the ground hen feather can be used as the fiber for reinforcement phase in composite materials.
2. To fabricate composite material by varying the proportion of the matrix phase and reinforcement phase i.e. mainly:
    - 1:7 -> fiber: resin by weight
    - 1:9 -> fiber: resin by weight
3. To test fabricated material under UTM machine to check its tensile strength.
4. Comparing the tensile strength and density with the different bio composite materials.

MARKET SURVEY

Today chicken is widely used as food everywhere. It produces the lot of organic waste. The lacs of tones waste is producing every day, handling of this waste is becoming very difficult because major part of this waste is feather and its take more than twenty years to bio degrade. Also it is not reused anywhere. So we decided to reuse this material as a fiber to prepare composite material.

Below table shows the quantity of waste produced from poultry farms and chicken centers near our college.

Table no.1:

No. of poultry farms	Avg. capacity/batch	No. of batches/year	Total hens/year	place
7	5000	5	175000	Nidasoshi

No. of chicken centers	Avg. requirement/day	Waste produced/hen	Feather wt./hen	place

5	20	300 gm	70 gm	sankeshwar

After survey we came to know that from sankeshwar(Karnataka) only the feather waste produced is about 2550 kg/year. So we have lot of material world wide that can be reused effectively.

Literature Survey

We studied the different types of resins, fibers and their properties to select the desired materials which will give the desired mechanical properties.

Types of Fibers

1. GLASS FIBER

E-glass (electrical)-lower alkali content and stronger than A glass(alkali). Good tensile and compressive strength and stiffness, good electrical properties and relatively low cost, but impact resistance relatively poor.

2. Carbon Fiber

Carbon fiber is produced by the controlled oxidation, carbonization and graphitization of carbon-rich organic precursor which are already in the fiber form. The most common precursor is polyacrylonitrile(PAN),because it gives the best carbon fiber properties ,but fibers can also be made from pitch or cellulose. Variation of the graphitization process produces either high strength fibers (@~2600˚C) or high modulus fibers (@~3000˚C) with other types in between. Once formed, the carbon fiber has a surface treatment applied to improve matrix bonding and chemical sizing which serves to protect it during handling.

3. ARMED FIBER

This is the generic name for fibers produced from aromatic polyamide fibers. The company Do-pont produces these fibers under the trade name Kevlar fibers.Kevlar fibers are compound based on benzene rings. The basic structure of Kevlar consist of Para substituted aromatic unit which gives the rigidity to the structure.

Categories of natural fibers

Natural fiber materials are derived from several sources within nature andthe agricultural community. These materials are basically "cellular" in formand structure with a degree of inherent strength and stiffness built in"naturally" due to the geometric internal structure. One of the basic cellularmaterials is cellulose. As a natural polymer itself, it possesses vety highstrength and stiffness per unit weight--exaccly the type of performancethat drives today's advanced composites technologies. Cellulose forms long,fiber-like cell structures that are found in wood cores and stems, leafmaterials, and seed materials. These are the three dominant sources fornatural fiber materials.

Table 1 shows the three basic categories of natural fiber sources aIid theircharacteristics. Each of these sources has a spot for their use within thecomposites industry. Natural fiber resources also provide materials morecommonly used in sandwich construction (core) designs with more wellknown materials such as balsa wood, reed, and bamboo forms. For thisarticle, we will not cover the sandwich structures but will concentrate moreonshonfibei and con"tinuous fiber forms.

Bast Fiber: The "bast" fiber family generally consistsofflax, hemp, jute,kenaf, and ramie ("China Grass"). These fibers are derived from wood coreand stem materials. The wood core is basically surrounded by the stem andthe stem consists of a number of fiber bundles. Cellulose is the primarychemical basis for the fJament structure that makes up the fiber bundles.The cellulose is the essential filament and is bonded or held together by anatural "resin" from either the lignin or pectin family. (Note: The intent isnot to get too heavy on "chemistry stuff" here, so we will tread lightly andjust cover things in general.)During the processing to obtain the natural basttypefibers, the pectin is removed during the systemthat leaves only the filaments and lignin. The fibersare processed into suitable reinforcement forms thatinclude short fibers (5-30 mm), continuous fibers ortextile-type fiber forms. In order to fabricate a traditionalcomposite, the resin system chosen to bond thefibers within the structure is used to impregnate thefiber structure using a number of available processing methods. However, the lignin actually is a weak linkin the critical interface bond region between

thenatural fiber and the incoming structural resin matrix.The lignin material between the cells of the fibers,being the weakest link, is not desirable and everyattempt is made to remove it or treat the fibers chemicallyto enhance the resin bond later.
Flax has a fairly high level oflignin.

Leaf Fiber: Leaf fibers include sisal, abaca (from the banana plant), andpalm materials. These fibers tend to be much coarser than the bast-typefibers overall. We have probably heard of sisal more than any of the othersin the group. Sisal is the most important and has a relatively high stiffnesscompared to the others.

SeedFibers: The last group, seed fibers, covers cotton, coir (coconuthusk materials), and kapok materials. Cotton is easily recognized for itswidespread international use in textiles and other fibrous products withinthe clothing and rope industries. Coir obviously is a much more durable,thick and course fiber material as we probably know just from picking upa coconut husk. Many of these materials are used for upholstery and"stuffing" furniture products.

Natural fiber properties provide variety

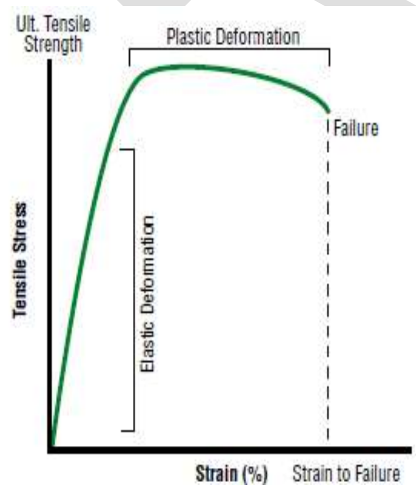
We have already noted that there are basically three fiber categories as shown in Table 1. The densities of all of the natural fibers lie roughly in the 1.25·1.51 g/cm3 range. With E-glass fiber sitting at 2.57 g/cm3, this means that(he natural fibers are 50-60 percent of the E-glass density. This is one ofthe major drivers for natural fiber composites on a weight basis alone.Aramid fibers, traditionally among the lightest weight materials for truestructural composites, is somewhere in the middle of the natural fibers atroughly 1.42 g/cm3.

- Resin

Matrix resins bind feather fibers together, protecting them from impact and the environment. Quill fiber properties such as strength dominates in continuously reinforced composites. When quill fiber is used in discontinuous reinforcement, resin properties dominate and are enhanced by the quill fiber.

- Mechanical properties of the Resin system

The figure below shows the stress/strain curve for an 'ideal' resin system. The curve for resin shows high ultimate strength, high stiffness (indicated by the initial gradient) and a high strain to failure.



Adhesive properties of the resin system

High adhesion between resin and reinforcement fibers is necessary for any resin system. This will ensure that the loads are transferred efficiently and will prevent cracking or fiber/resin debonding when stressed.

Toughness properties of resin system

Toughness is a measure of a material's resistance to crack propagation, but in a composite this can be hard to measure accurately. However, the stress/stain curve of the resin system on its own provides some indication of the material toughness. Generally the more deformation the resin will accept before failure the tougher and more crack resistant the material will be.

Conversely, a resin system with a low strain to failure will tend to create a brittle composite, which cracks easily. It is important to match this property to the elongation of the fiber reinforcement.

Environmental properties of the resin system: Good resistance to the environment, water and other aggressive substances, together with an ability to withstand constant stress cycling, are properties essential to any resin

system. These properties are particularly environmental properties of the resin system important for use in a marine environment.

Types of resins

Polymer matrix resin fall into two categories:

1) Thermoset.
2) Thermoplastic.

Thermoset

With their track record of performance, Thermoset have become the matrix of choice in continuously reinforced glass fiber composites and plastic parts made with glass filler. Especially popular are unsaturated polyester resin, which are relatively in expensive, easy to handle, and have good mechanical, electrical and chemical resistance.

Polyester

These are named for their ingredients, such as orthopolyster(utilizing orthopathalic acid), isopolysters(resins containing isopathalic acid for superior chemical and thermal resistance),and terephthalic resins (formulated with terephthalic acid for improved toughness).

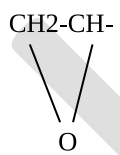
Vinyl esters

Cost more than polysters but are used in many of the some applications.their performance surpasses polysters in chemically corrosive environments (such as filament would glass/vinyl ester chemical tanks)and structural laminates requiring high moisture resistance(such as boat manufacturing).

Epoxy resins

The large family of epoxy resins represents some of the highest performance resins of those available at this time. Epoxies generally out-perform most other resin types in terms of mechanical properties and resistance to environment degradation, which leads to their almost exclusive use in aircraft component. As laminating resins their increased adhesive properties and resistance to water degradation make these resins ideal for use in applications such as boating building. Here epoxies are widely used as a primary construction material for high performance boat or as a secondary applications to sheath a hull or replace water degraded polyester resins and gel coats.

The term 'epoxy' refers to a chemical group consisting of an oxygen atom bonded to two carbon atoms that are already bonded in some way.the simplest epoxy is a three member ring structures known by the term 'alpha-epoxy' or '1,2epoxy'.the idealized chemical structure is shown in the figure below and is the most easily identified characteristic of any more complex epoxy module.



IDEALISED CHEMICAL STRUCTURE OF SIMPLE EPOXY(ETHYLENE OXIDE)

Epoxy differ from polyster resins in that they are cured by a 'hardener'rather than a catalyst.thehardner,often an amine,is used to cure the epoxy by an 'additional reaction' where both materials take place in the chemical reaction.the chemistry of this reaction means that there are usually two epoxy sites binding to each amine site.this forms a complex three-dimensional molecular structure.

Since the amine molecules 'co-react' with the epoxy molecules in a fixed ratio, it is essential that the correct mix ratio is obtained between resin and hardner to ensure that a complete reaction takes place. If amine and epoxy are not mixed in the correct ratios,unreacted resin or hardener will remain within the matrix which will affect the final properties after cure. To assist with the accure mixing of the resin and hardner,manufacturers usually formulate the components to give a simple mix ratio which is easily achieved by measuring out by weight or volume.

Thermoplastic:

While Thermoset are more widely used, thermoplastic resins are in a significantly wider range of matrix choices. Higher in cost, they are also high-performance, withstanding temperature up to 400 degrees F & beyond. Besides elevated temperature performance, thermoplastic.

The most common commodity thermoplastic is polyethylene, polystyrene, polypropylene & thermoplastic polyesters (PET,PBT). Melt flow & density options, enhanced impact resistance & relative's case processing characterize them.

Thermoplastics reinforced with non-continuous fiberglass are used to manufacture a wide range of consumer, commercial & light industrial products. Because of its high processing temperatures, thermoplastics are not effective in hand lay-up & spray-up fabrication projects, unless high performance mechanical properties are demanded.

Advantages of Thermo –plastics:

- Soften on heating & application of pressure.
- Can accommodate high strains before failure.
- Indefinite shell life.
- Can e reprocessed.
- Short curing cycles

Resin comparison:

The polyesters, Vinylesters and epoxies discussed here probably account for some 90% of all thermosetting resin systems used in structural composites. In summary the main advantages of each of these types are:

Polyesters

Advantages:

- Easy to use.
- Lowest cost of resins available

Disadvantages:

- Possess moderate mechanical properties
- High styrene emissions in open moulds
- High cure shrinkage limited range of working times.

Vinyl esters

Advantages:

- Very high chemical/environmental resistance.
- Higher mechanical properties than polyesters.

Disadvantages:

- Post cure generally required for high properties.
- High styrene content.
- High cure shrinkage.

Epoxies:

Advantages:

- High mechanical and thermal properties.
- High water resistance.
- Long working times available
- Low cure shrinkage.

Hardener:

A wide variety of curing agent for epoxy resin is available depending on process & properties required. The commonly used curing agents include amines, polyamides,Phenolics resinanhydrides, isocyanatespolymercaptanes. The choice of resin and hardener depends upon the application, the process selected and properties desired. The stoichiometry of the resin-hardener system also effects the properties of the cured material.

- The following table gives the comparison between various properties of the different natural fibers
  - Young's modulus and densities of various natural fibers :-

Table no.2:

Fiber	*Young's modulus*	*Density*
• jute -	8 to 20 GN/m2	1.3 gm/cm3
• Banana –	9 to 16 GN/mm2	1.35 gm/cm3
• Siesel -	34 to 82 GN/m2	1.45gm/cm3

IJERGS

- Coir - 4 to 6 GN/m2 1.15 gm/cm3
- Cotton – 27 GN/m2 1.52 gm/cm3
- QUILL – 3 to 50 GN/m2 0.89 gm/cm3

Aspect ratio:

It is the ratio of length to the diameter of the material.
For safe working aspect ratio should be greater than 15.

That is $\frac{l}{d} \geq 15$

Below Table shows the Dimension and Measuring of the randomly selected Quills:

Table no.3:

Model no	Point no	Diameter in mm	Average diameter	Length in cm
1	A	2.66	1.74	15.4
	B	1.83		
	C	0.73		
2	A	2.17	1.31	14
	B	1.16		
	C	0.59		
3	A	1.66	1.31	11.4
	B	1.68		
	C	0.59		
4	A	2.56	1.65	14
	B	1.67		
	C	0.72		
5	A	2.66	1.656	12.9
	B	1.65		
	C	0.66		
6	A	2.07	1.4	13.5
	B	1.5		
	C	0.63		
7	A	2.4	1.51	12.5
	B	1.63		
	C	0.5		
8	A	2.42	1.53	14
	B	1.53		
	C	0.64		
9	A	2.44	1.456	15
	B	1.47		
	C	0.46		
10	A	2.44	1.41	14.1
	B	1.33		
	C	0.46		
11	A	2.67	1.86	12.5
	B	1.86		
	C	1.12		
12	A	2.78	1.66	15.4
	B	1.75		
	C	0.46		
13	A	2.28	1.32	14.3
	B	1.25		
	C	0.43		

14	A	2.78	1.487	15.4
	B	1.67		
	C	0.42		
15	A	2.05	1.22	12.3
	B	1.14		
	C	0.48		
16	A	2.71	1.656	13.4
	B	1.68		
	C	0.58		
17	A	2.89	1.686	16.1
	B	1.67		
	C	0.50		
18	A	2.67	1.516	16.2
	B	1.52		
	C	0.36		

For example the Aspect ratio for 1st model in the above table is given as:

l/d=154/1.74

=88.5 > 15

The tensile test conducted on the quill material gives the following results

Specimen-1

The average dia = 1.6405 mm Length = 138.9 mm

The maximum load carried:-35 N

Extension at maximum load: - 0.375 mm

Tensile stress = load/area

= 35/2.1137

= 16.558 N/mm2

Young's modulus = 16.558/0.375

= 44.154 N/mm2

Specimen- 2

The average dia = 1.594 mm Length = 145.6 mm

The maximum load carried:-37 N

Extension at maximum load: - 0.896 mm

Tensile stress = load/area

= 37/1.995

= 18.541 N/mm2

Young's modulus = 18.541/0.896

= 20.693 N/mm2

From the above calculation we can see that the young's modulus of the quill is very similar to the young's modulus of the materials listed in the table no.2. Therefore we can use the quill as the fiber material in composite material.

Phenolics are the example of polymer matrix. It is superior in high temperature applications for many years. It is available with low viscosity version that is easier to process and including those with low volumes.

Phenolics are particularly useful in composite parts that must meet smoke emission, combustion of toxicity requirements. They can be found in panels of flooring of aircrafts, rotor blades of helicopters, automobile bodies, marine applications, bicycles frames etc.

Phenolics offer low density, good thermal insulation, outstanding durability, and easy of formability to complex contours

With their reduced cost, light weight of other advantages, glass reinforced Phenolics have replaced metal in automotive components.

PRELIMINARY PROCEDURE TO PREPARE THE FIBER

1. Collecting material
2. Cleaning the material
3. Soaking
4. Separation of barbs from quill
5. Trials for alignments

1. Collecting material: The row material was collected in the forms of wings form chicken centers sankeshwar.(Karnataka)

2. Cleaning the material:- By keeping the material in hot water feather get loosen from bone and separate by wearing hand glows. Then by using detergent powder the blood, bacteria's and flesh particle from remove feather.

3. Soaking:-Clean feathers were soaked under sun light for whole one day.

5. **Separating barbs form quill:-**By using sharp tools like blades and seizers barbs were separated from the quill fibers and collected separately.

5. by crushing the quill:- Due to the problem to get the composite material in various or complex shapes it require crush the quill fiber by using plastic crushing machines used in plastic industries or by using domestic mixer, and mix it with barbs to get mixture suitable to make mat's

PREPARATION OF SLABS:-Fiber reinforce polymer matrix composite are produced from basic building blocks namely fibers,rein,fillers &gel coats etc. followingprocesses are available for the production of the desired product

- **Open moulding process**

A. Hand lay-up process

B. Spray up process

- **Bag moulding process**
  C. Pressure bay moulding
  E. Vacuum bay moulding
  F. Auto clave
- **Compression moulding**
- **Matched die moulding or resin transfer moulding**
- **Filament winding**
- **Injection moulding**
- **Thermo forming**
- **Blow moulding**

HAND LAY-UP PROCESS

Description: Hand lay-up is the oldest and simplest method used for producing reinforced plastic laminates. Capital investment for hand lay-up process is relatively low. There is virtually no limit to the size of the part that can be made. The fiber reinforcement which is normally in the form of a woven cloth or chopped strand mat or crushed material is laid first. The plastic resin mixed with hardener is then applied by using brush. Rollers are used to thoroughly wet the resin matrix material to enable good compaction and to remove entrapped air. To increase the thickness of the composite material being produced; more layers of the fiber and resin are added. Applications of this method include boat hulls, tanks, housing, chairs etc.

Hand lay-up process is particularly suitable under the following conditions:

- Only one side needs smooth finish.
- Slight variation in thickness is permissible.
- When product size is large and complex in shape
- Labor charges are not prohibitively high.
- Only a few moldings are required.

  Different stages of hand lay-up process are as under:
  - Raw material preparation.
  - Laying up.
  - Curing.

- **Raw material preparation:**

1.Preparation of reinforcementsChopped strands mat and crushed material of quill fibers are the reinforcement materials used. The preparation of these materials is explained all ready. for the strand mats the quill fibers are trimmed to suit the size of the product.

2.Preparation of the resin matrix:The resin stored at low temperatures with stabilizers added to it. this is done to prevent the gelling. The resins are in liquid phase. The resin is mixed with the hardener in the prescribed ratio. After adding the hardener to the resin only the gelling process starts.

3. Laying-up: When the initial materials are ready, then the resin mix is coated on the aluminum foil of thickness about 0.5 mm uniformly. A soft brush is used to apply the resin. After that the quill fiber layer is placed uniformly on the resin applied area. If it is a crushed fiber then a roller is to uniformly distribute the fiber material on resin. After this once again the resin mix I applied on the fiber surface. The process is repeated until the desired thickness is obtained.

To get fine surface finish on the upper side of the material an aluminum foil is placed and rolled uniformly.

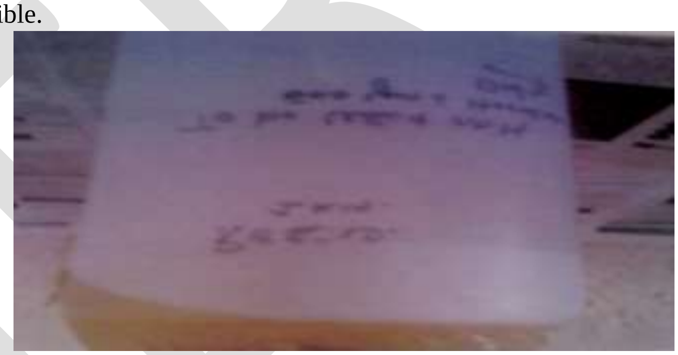
4.Curing: Curing is very important stage in the hand lay-up process. The final strength of the material depends on the curing time. As the curing time increases the strength of the material is also increases. The curing has to be carried out under the pressure so that a compact material with less porosity can be obtained. And it can be done under room temperature also. But it depends on the properties of resin.

Advantage of hand lay-up process:

1. Process is extremely simple.
2. Simple principle to teach
3. The process does not require sophisticated machinery and tools.
4. Simple accessories like mugs, brushes are adequate.
5. Highly suitable for part of large and complex shapes.
6. Contours and surface finish can be imparted according to the need of the customer.

Disadvantages of hand lay-up process:

1. Techniques arelabour intensive.
2. Process is not amenable when smooth finish is required on both sides.
3. Thickness cannot be controlled.
4. It is difficult to obtain uniform fiber to resin ratio at all places.
5. Mass production is not possible.



MATERIALS SELECTED

From the above literature survey we have selected the fallowing materials for fabrication of required composite material.

✓ **RESIN**

SPECIFICATIONS:

TYPE	boat polyester resin (Phenolics)	Epoxy resin
Density(gm/cc)	1.2	1.14
Tensile strength (MPa)	50 to 55	63-70
Youngs modulus(GPa)	15 to 35	26-43
Coefficient of thermal expansion(/℃)	4.5 to 11*10^-5	4.8 to 13*10^-5

✓ **SPECIFICATIONS OF HARDNER:**

Type- k-46 (atulceba),Density -850 kg/m3
Cost –Rs100 /kg ,Mixture ratio-1:10
CASE-1 BY WEIGHT
1:9-FIBER: RESIN

Weight of the fiber – 16 gm.
Weight of the resin – 144 gm.
Total weight – 160 gm.
Volume of the composite material -163100 mm3.
Density of the composite material – 0.98 gm/cm3
CASE-2BY WEIGHT
1:7-FIBER: RESIN

Weight of the fiber – 38 gm.

Weight of the resin – 266 gm.

Total weight – 304 gm.

Volume of the composite material – 220220 mm3.

Density of the composite material – 1.38 gm/cm3.

CASE-3 BY WEIGHT
1:8

Weight of the fiber – 33 gm.
Weight of the resin – 264 gm.
Total weight – 297 gm.
Volume of the composite material – 268625 mm3.
Density of the composite material – 1.105gm/cm3.

COMPARISON WITH OTHER MATERIALS

properties	E-glass	Flax	Jute	Hemp	Cotton	Ramie	Coir	Sisal	**quill**
Density,g/cm3	2.57	1.40	1.46	1.48	1.51	1.50	1.25	1.33	**1.18**
Tensile strength,Pa	3450	800-1500	400-800	550-900	400	500	230	600-700	**7**
Specific modulus	28	25-45	7-20	45	8	30	5	30	**3-10**
Elongation,%	4.8	1.2-1.6	1.8	1.6	3-10	2	15-25	2-3	**1.167**

In the above table the various properties of the natural fiber composite are compared with quill fiber composite. The properties like density elongation and specific modulus are comparatively good or similar. But the tensile strength is less than other the use of resin effects the tensile strength of material. Also the curing period play very important roll to determine strength of material, so to get higher tensile strength the high quality resin can be used with enlarged curing period.

APPLICATIONS

- Aerospace industry
- Electronics and marine industry
- Automotive industry
- Pallets and Building material
- Helmet making material

CONCLUSION:

The animal products like hair, bird's feathers, quills etc. can be used as fiber materials. It is anticipated that by incorporating quill particulates into polypropylene/epoxy resin matrix, the composite materials can be produced which can give good mechanical with low weight. Also the quill being the waste product of the poultry industry, the final cost of the composite product will be too low compared to other biological composite material. Meanwhile the problem of poultry solid waste handling can be solved.

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