# EXPERIMENTAL INVESTIGATION ON NATURAL FIBER BIOCOMPOSITES BY USING DESTRUCTIVE TESTING

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***Abstract:*** The primary objective of the paper deals with the process of making natural fiber biocomposites which are derived from the coconut shell powder and walnut shell powder which are derived from the extraction process. It is also investigates the determination of tensile strength, impact strength and hardness of the bio composite materials made with coconut shell powder and walnut shell powder under loading with different mechanical or destructive tests have been carried out. The behavior of the same is determined in terms of ultimate tensile stress and ultimate yield stress which can be compared with steel specimen as reference. Uniform distribution of fiber particles are observed during Metallographic test.

**Keywords:** *Composite materials, Fiber-reinforced Plastic, Destructive Testing, Resin matrix material, Tensile Strength, Coconut Shell Powder, Walnut Shell Powder*

## I.INTRODUCTION

Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of uses of composite materials have developed consistently, infiltrating and vanquishing new markets determinedly. Present day composite materials constitute a critical extent of the designed materials showcase extending from regular items to advanced specialty applications. While composites have officially demonstrated their value as weight-saving materials, the present test is to influence them to financially savvy. The endeavors to deliver monetarily appealing composite segments have brought about a few inventive assembling strategies right now being utilized as a part of the composites business. It is self-evident, particularly for composites, that the change in assembling innovation alone isn't sufficient to defeat the cost jump. It is essential that there be an integrated effort in design, material, process, tooling, quality assurance, manufacturing, and even program management for composites to become competitive with metals. The composites business has started to perceive that the business uses of composites guarantee to offer substantially bigger business openings than the aviation part because of the sheer size of transportation industry. In this manner the move of composite applications from air ship to other business utilizes has turned out to be unmistakable as of late. Progressively empowered by the presentation of more up to date polymer gum grid materials and elite support filaments of glass, carbon and aramid, the entrance of these propelled materials has seen a consistent development in employments and volume. The expanded volume has brought about a normal decrease in costs. Elite FRP would now be able to be found in such various applications as composite protecting intended to oppose unstable effects, fuel barrels for gaseous petrol vehicles, windmill cutting edges, mechanical drive shafts, bolster light emissions connects and even paper making rollers. For specific applications, the utilization of composites instead of metals has in reality brought about funds of both cost and weight.

### 1.2.1. EXAMPLES OF COMPOSITES

The most common example of a "composite" in a broad sense is concrete. In this utilization, auxiliary steel rebar gives the strength and stiffness to the solid, while the cured concrete holds the rebar stationary. Rebar alone would flex excessively and concrete alone would split effectively. Be that as it may, when consolidated to frame a composite, as great degree inflexible material is made. The composite material most regularly connected with the expression "composite" is Fiber Reinforced Plastics. This type of composite is used extensively throughout our daily lives. Common everyday uses of fiber reinforced plastic composites include:

Aircraft, Boats and marine

Sporting equipment (Golf shafts, tennis rackets, surfboards, hockey sticks, etc.)

Automotive components, Wind turbine blades

Body armor, Building materials

Water pipes, Bridges

Tool handles, Ladder rails

## 2. CLASSIFICATION OF NATURAL FIBER

[3][4] A Natural fiber made from plant, animal or mineral sources, and is classified according to the origin. Plants that produce natural fibers are categorized into primary and secondary depending on the Utilization. Primary plants are grown for their fibers (examples, Jute, hemp, kenaf, and sisal) while secondary plants are plants where the fibers are extracted from the waste product (examples, Pineapple, Bagasse, oil palm and coir). There are six major types of fibers namely; bast fibers (jute, flax, hemp, ramie, baggasse, linen, bamboo, and kenaf), leaves fibers (abaca, banana, sisal and pineapple), leaflets (palm, coconut, etc.) seed fibers (coir, cotton and kapok), grass and reed fibers (wheat, corn and rice) and all other types (wood and roots). A large variation is found in the mechanical and physical properties of natural fibers. Those properties are affected by many factors of natural fibers. The experimental conditions are different such as type of fibers, moisture content and form of fibers (yarn, woven, twine, chopped, felt, etc.). Moreover, the properties are also affected by the place where the fibers are grown, cultivation condition. The part of the plant they are harvested from growing period and retting or extracting process.

## 3. WORK FLOW FOR BIO COMPOSITE PROCESSING

[3]The uncrushed natural fibers were cleaned, dried at room temperature or atmosphere air and Chemical treated using Isocyanate, washing with an alkaline solution and hardener were applied. After treatment, the natural fiber was dried in an oven at 500°C to1200°C for 1 to 24 hours or atmospheric air at 24 to 48 hours depending upon the method. And then to reduce the size in ball milled at 200 to 300 RPM for 5 to 6 hours. [3][4] The natural fiber and polymer matrix were mixing in the reactor or z-blade mixer or two-roll the mixer. [7]After the mixing composites were compressed under pressure from 10Mpa to 150Mpa at 1500°C to 1800°C for 5 to 10 minutes and finally dry the composites in dry air for proper curing.

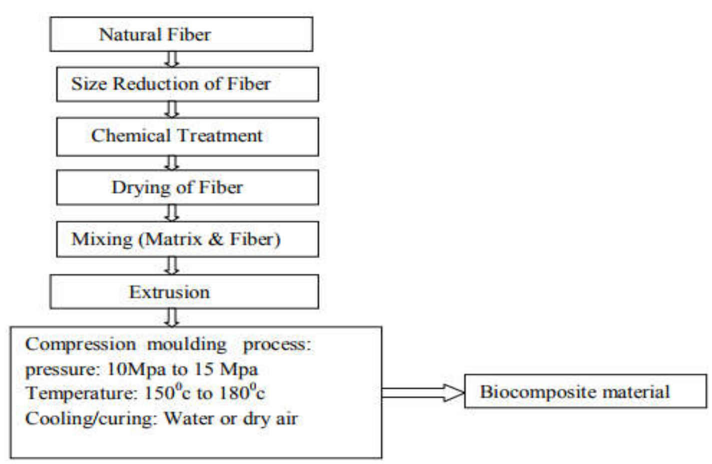



Fig 1: Work flow procedure to obtain the Biocomposites Material Extraction

**[6] [7] Fibrous Composites Short fiber reinforced composites:**

Short-fiber reinforced composites consist of a matrix reinforced by a dispersed phase in form of discontinuous fibers (length < 100*diameter). They are classified as Composites with random orientation of fibers. Composites with preferred orientation of fibers. Long-fiber reinforced composites: Long-fiber reinforced composites consist of a matrix reinforced by a dispersed phase in form of continuous fibers. Unidirectional orientation of fibers. Bidirectional orientation of fibers (woven).Laminate composite when a fiber reinforced composite consists of several layers with different fiber orientations, it is called multilayer composite. *[3][8] Fillers* are the next materials in terms of volume that is required in the plastic industry apart from the base polymers. Thermo set commonly used fillers in plastic industries are mineral fillers and natural fillers. Presently, natural fillers are being used as alternative to conventional mineral fillers in compounding of plastics so as to enhance the properties of the plastics and reduce the over dependent on the petroleum-based resources due to high rate of depletion of the natural resources. [8]In addition, to the overcome the other limitations associated with the use of mineral fillers (especially glass fiber, talc, asbestos, silica, mica, etc) in plastic industry which include high cost, non biodegradable, loss of energy during processing, abrading of processing equipment, and increase in the density of composite systems, nonrenewable and abundant resource and its hazardous effect on environment. However, the disadvantages of the natural fillers are summarized as follow; degradation by moisture, poor surface adhesion to hydrophobic polymers, non-uniform filler sizes, not suitable for high temperature application, susceptibility to Fungal and insect attack, etc .Polypropylene is a commodity thermo plastic the offers a combination of outstanding physical, chemical, mechanical, thermal and electrical properties not found in any other thermoplastic. It has a lower impact strength compared to low or high density polyethylene, but superior working temperature and tensile strength.

## 4. COCONUT SHELL POWDER

Coconut is an individual from the palm family, which is one of the nourishment trims on the planet. It creates a lot of waste material, to be specific coconut shell (CS). CS is non-sustenance part of coconut which is one of the hard lignocelluloses agro squanders. Agro squander items, for example, CS is a yearly increment consistently and is accessible in plentiful volume all through the world. Especially CS is a standout amongst the hugest characteristic fillers created in tropical nations like India, Malaysia, Indonesia, Thailand and Srilankha. A few laborers have been devoted to utilization of other characteristic fiber in composite in the most recent post and CS fiber is a potential possibility for the change of new composites in light of their high quality and modulus properties. Composite fiber can be utilized as a part of, the board scope of utilization, for example, building material, furniture and fishnets. Coconut fiber is essential fortification material in creation of different sorts of polymer based composites, because of cost adequacy, high quality, and so forth. Directly 90% CS was arranged as waste and either consumed in the outdoors or left Seattle in squander lakes. Along these lines the coconut handling ventures squander as indicated by him contributed fundamentally to CO2 and methane emanations. Based on economic as well as environmental related issues, this effort should be directed worldwide towards coconut management issues i.e. of utilization, storage and disposal. Different avenues of CS utilization are more or less known, but none of them have so far proved to be economically viable or commercially feasible

Fig 2: Coconut Powder from the coconut shells (CS)

Coconut shell is low ash remains content. Transformation of coconut shells into enacted carbons which can be utilized as adsorbents in water refinement and city effluents would increase the value of these rural products, help decrease the cost of waste transfer and give a conceivably shabby other option to existing business carbons.

## PRODUCT SPECIFICATION & USES

There is no specification prescribed by Bureau of Indian standards for coconut shell powder. This is manufactured as per our requirement and the particle size varies depending upon its end uses. The following specification is normally followed.

Appearance : Clear light brown free flowing
Powder Moisture: Maximum 10% Apparent
Density : 0.6 to 0.7 gm/cc
Ash : Shall not exceed 1.5%

[2] Manufacturing Processes of Composite Material Manufacturing of a composite material is to combine the polymeric resin system with the fiber reinforcement. Since the orientation of the fibers is critical to the end Properties of the composite, manufacturing process is utmost important to align the fibers in desired direction. A good manufacturing process will produce a higher, uniform fiber volume fraction along with a higher production of a large volume of parts economically and have repeatable dimensional tolerances. [5][7]Hand lay-up is an open molding method suitable for making a wide variety of composites products from Very small to very large. Production volume per mold is low; however, it is feasible to produce substantial Production quantities using multiple molds. Hand lay-up is the simplest composites molding method, offering low cost tooling, simple processing, and a wide range of part sizes. Design changes are readily made. There is a minimum investment in equipment. With skilled operators, good production rates and consistent quality are obtainable.

## [5] Materials and methods:

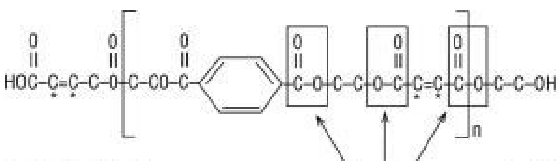
This chapter deals with the materials that are used in the present study and the methods by which these materials are processed. The materials that are used in the present concern of
Studies are:

1. Matrix material
   a. Coconut shell powder
   b. Walnut shell powder
2. Filler materials

**Matrix material:** The matrix is basically a homogeneous and monolithic material in which a fiber system of a composite is embedded. It is completely continuous. The matrix provides a medium for binding and holding reinforcements together into a solid. It offers protection to the reinforcements from environmental damage, serves to transfer load, and provides finish, texture, color, durability and functionality. Polyester resin: [4] Polyester resins are the most widely used resin systems. Most polyester resins are viscous, pale colored liquids consisting of a solution of polyester in a monomer which is usually styrene. The addition of styrene in amounts of up to 50% helps to make the resin easier to handle by reducing its viscosity.

Fig 3: Polyester resin

The figure below shows the idealized chemical structure of typical polyester. Note the positions of the ester groups (CO - O - C) and the reactive sites (C* = C*) within the molecular chain.



***Denotes reactive sites**

Fig 4: Chemical structure of polyester

These resins can therefore be molded without the use of pressure and are called 'contact' or 'low pressure' resins. Often small quantities of inhibitor are added during the resin manufacture to slow this gelling action. For use in molding, a polyester resin requires the addition of several ancillary products. These products are generally:


Fig 5: Polyester resin

**Cobalt Octoate:**

Cobalt octoate being the most effective drier promotes polymerization of media, hardens the paint film, improves gloss and water resistance and reduces brittleness of film. The careful use of Cobalt octoate gives the paint film a good gloss, free from frosting tendency. This drier is a universal drier, which is essential in all the media and is capable of performing individually giving reasonable properties to the paint film. In air-drying type insulating varnishes use of Cobalt octoate increases water resistance. Cobalt octoate accelerates the catalytic action of Methyl ethyl ketone (M.E.K.) Peroxide to polymerize unsaturated polyester resin.

**Ester grou**


Fig 6: Cobalt Octoate

## Methyl Ethyl Ketone Peroxide (MEKP)

MEKP is an organic peroxide, a high explosive. MEKP is a colorless, oily liquid; MEKP is slightly less sensitive to shock and temperature, and more stable in storage. Depending on the experimental conditions, several different adducts of methyl ethyl ketone and hydrogen peroxide are known. MEKP Catalyst for polyester resin including our GP Polyester Resin, Clear Polyester Gel Coat and Unmold system. MEKP Catalyst is typically added to polyester resin at a ratio of between 1 and 3%, according to the pot-life and cure speed required and the ambient temperature. Always follow the guidelines that accompany your specific resin system

Fig 7(a): Walnut Fiber Bio Composite

Fig 7(b): Coconut Fiber Bio Composite

## Destructive Testing and Results:

Metallographic Test:

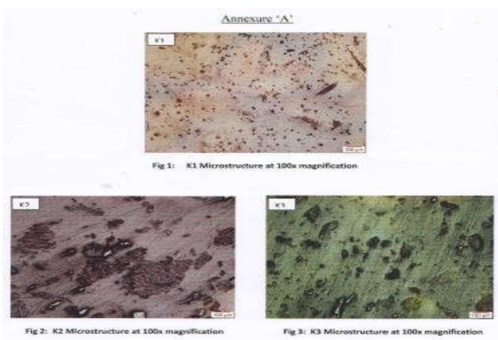


Fig 8: Microstructure of natural fibers

## [9]Tensile Test:

Fig 9: Specimens Prepared for testing

Force is applied perpendicular to the cross sectional area of the test item. Two of the essential material properties that tractable tests decide are:

- Yield Strength, which is the anxiety required to for all time extend, or twist, a material a particular sum, normally 0.2% of aggregate extension.
- Ultimate Tensile Strength, which is the most extreme anxiety a material can withstand only preceding cracking

Table 1: Tensile test Reports

| Specimen Parameters | Coconut shell powder | Walnut shell powder | Steel Specimen |
|---|---|---|---|
| Specimen type | Flat | Flat | Flat |
| Specimen width mm | 13.75 | 14.02 | 14.33 |
| Specimen width mm | 13 | 13.05 | 13.2 |
| Cross-section area,$mm^2$ | 178.75 | 182.961 | 189.156 |
| Original Gauge, mm | 50 | 50 | 50 |
| Final gauge, mm | 51.68 | 51.32 | 51.2 |
| Ultimate load, KN | 2.080 | 3.120 | 2.120 |
| Ultimate Tensile Strength, $N/mm^2$ | 14.636 | 17.053 | 11.207 |
| Elongation, mm | 1.360 | 2.640 | 2.400 |
| Yield Load, KN | 1.080 | 2.920 | 1.820 |
| Yield Stress, $N/mm^2$ | 9.042 | 15.960 | 6.621 |

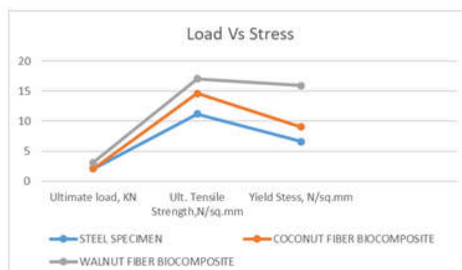



Fig 10: Mechanical Behavior of three specimens under loading

## [9]Hardness Test

Hardness is a normal for a material, not a basic physical property. It is characterized as the protection from space, and it is dictated by measuring the perpetual profundity of the space. This test is completed with understanding of ASTM D 2240.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HARDNESS TEST REPORT

Fig 11: Reports of Hardness Test

## [9]Impact Test

Amid the testing procedure, the example must be stacked in the testing machine and permits the pendulum until the point when it cracks or breaks. Utilizing the effect test, the vitality expected to break the material can be measured effectively and can be utilized to gauge the durability of the material and the yield quality. Impact tests measure resistance to shock loading or impact by determining the amount of energy absorbed by the test specimen. There are two basic types of impact tests:


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IMPACT TEST REPORT

Fig 12: Reports of Impact Test

## CONCLUSION:

- From the Metallography test, it has been observed that the uniform dispersion of fibers in both Bio composites made with walnut & coconut powder.
- With the help of universal testing machine, tensile test is done and it is determined that the ultimate tensile strength of coconut fiber bio composite and walnut fiber bio composite are 23.42% & 34.28 % higher than the steel specimen.
- Also, the yield stress shows drastic change in walnut fiber bio composite of 58.51% and coconut fiber bio composite has 26.77% as compared steel specimen.
- As per hardness test, coconut fiber shows 91 as its hardness number whereas walnut fiber shows 94.
- Finally, impact test shows only a sustainable value of 0.5 Joules.

## References:


1) Luo S. and Netravali A.N., *Polymer composites*. *20(3)* (1999) 367-378.
2) Sapuan, S.M., Harimi, M., Maleque M. A., *Journal of Tropical Agriculture, 43*(2005)1-2.
3) Ramazan Yildirim, *Production of polymer of Composite Board from Walnut Shell and improvements of its features*, 2005, M. Sc.Thesis
4) WichianbutY., Charoenyut Dechwayukul, Lek Sikong, Wiriya Thongruang on *Mechanical Properties of Lignite Fly Ash/Natural Rubber Composites: Effects of Filter Size, Loading and Silane Coupling Agent, Materials-2550, 10,* (2005).
5) Risby M.S. Wong S.V., Hamouda A.M.S., Khairul A.R., Elsadig M., *Def. Sci. J.*, *58* (2008) 248.
6) Singh, V. K., Gope, P.C., *Journal of Reinforced Plastics and Composites. 29(16)* (2010) 2450-2468.
7) Rashdi AAA, Sapuan SM, Ahmad MMHM, Khalina A. *Int. J.Mech. Mater. Eng*. 2010, *5,* 11 – 17. [8]. Nadir, A., Songklod *J., Fibers and Polymers. 12* (2011) 919-926.
8) Apasi A.,Madakson P.B.,Yawas D.S.,Aigbodion V.S., *Tribology in Industry.*,*34*(2012) 36.
9) Bhaskar J., Singh V.K., *J. Mater.Environ. Sci.*, *4* (2013) 113.

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