International Journal of Scientific Research in Mechanical and Materials Engineering
© 2021 IJSRMME | ISSN : 2457-0435

Finite Element Analysis of Groundnut Shell and Coir Fiber Mix Epoxy Composite Moulding and Testing

Anand Harinarayan Pagar*, Prof. Dr. S. R. Suryawanshi
Department of Mechanical Engineering, MET's Institute of Engineering, Nashik, Maharashtra, India

Article Info
Volume 5, Issue 2
Page Number : 17-20

Publication Issue :
March-April-2021

Article History
Accepted : 01 March 2021
Published : 04 March 2021

ABSTRACT

Current work has been done, with the aim of testing the strength of groundnut shell & Coir fiber polymer composites and studying the mechanical properties of composites and comparing the experimental outcomes with finite element analysis by using Ansys. Current work reports the use of groundnut & Coir fibres, as reinforcement in the polymer matrix. This review focuses on providing information to improve ongoing research in this area. The potential for surface chemical conversion of groundnut & Coir fibers has been widely used in a variety of applications, e.g., packaging, furniture etc. The current offering describes some of the selected functions in the field of groundnut shell and Coir fibers. The influence of the source of the groundnut shell & Coir fibre was reported on organic material. Several natural compounds of fiber complement the properties of fiberglass machinery and have already been used, e.g., in the furniture industry etc. Currently, the most important and cheap natural fibres are Jute, flax, bagasse and coir. The future of the groundnut shell & combination of coir fiber seems bright. The production of composite materials is therefore planned by mixing coir fiber and earth shell in epoxy and Araldite and testing its strength at UTM. The material was modelled and resembled as a representative volume element using suitable assumption and analysed by means of finite element method using ANSYS software for determining the deflection and stress properties. From the results, it's been found that the finite element values are acceptable with proper assumptions, and therefore the prepared natural fiber composite beam material are often used for various engineering applications.

Keywords: Groundnut shell, Green Composites, Matrix, Coir Fibers, Mechanical Testing, Finite Element Analysis.

I. INTRODUCTION

Composite materials have a long history of usage. Their precise beginnings are unknown, but all recorded history contains references to some form of composite material. For example, straw was used by the Israelites to strengthen mud bricks. Plywood was used by the ancient Egyptians when they realized that wood could be rearranged to achieve superior strength arid resistance to thermal expansion as well as to swelling caused by the absorption of moisture. More recently, fiber-reinforced, resin-matrix composite materials that have high strength-to-weight and stiffness-to-weight ratios have become important in weight-sensitive applications such as aircraft and space vehicles.

The advantage of composite materials over conventional materials stem largely from their higher specific strength, stiffness and fatigue characteristics, which enables structural design to be more versatile. By definition, composite materials consist of two or more constituents with physically separable phases [1, 2]. However, only when the composite phase materials have notably different physical properties it is recognized as being a composite material.

Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix). Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position and orientation of the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties; yet together they produce a combination of qualities which individual constituents would be incapable of producing alone. The reinforcement may be platelets, particles or fibers and they are usually added to improve mechanical properties such as stiffness, strength and toughness of the matrix material.

Some of the things that can be improved by building a composite object are-

1. Strength
2. Fatigue Life
3. Stiffness
4. Temperature-Dependent Behaviour
5. Corrosion Resistance
6. Electric Insulation
7. Attractiveness
8. Acoustical Insulation
9. Low Weight and space vehicles

A. SCOPE OF WORK:

The compounds are able to meet a variety of design requirements with significant weight savings and a high amount of strength and weight compared to conventional materials. Some of the benefits of over-the-counter items are listed below:

1. The strength of the composite is equal to that of steel and aluminium.
2. Improved tensile strength and impact structures
3. Higher limit of fatigue tolerance (up to 60% of the maximum strength strength).
4. 30-45% is lighter than aluminium structures designed for the same operating requirements.
5. The embedded strength is low as compared to other building materials such as steel, aluminium etc.
6. The compounds are less noise while operating and offer lower vibration vibrations than metal
7. Combinations work in many ways than steel and can be tailored to meet operational and complex construction requirements
8. Long life provides excellent fatigue, impact, environmental resilience and reduced maintenance
9. Combinations enjoy reduced life cycle costs compared to metals
10. The compounds show excellent resistance to corrosion and fire delays
11. Improved appearance with smooth surfaces and easily embellished melamine embellishments for other construction features
12. Combined parts can remove joints / joints, providing easier simulation and compact construction compared to conventional metal parts.

B. Types of Composite Material:

For the sake of simplicity, however, composites can be grouped into categories based on the nature of the matrix each type possesses. Methods of fabrication also vary according to physical and chemical properties of the matrices and reinforcing fibers.

(a) Metal Matrix Composites (MMCs)

Metal matrix composites, as the name implies, have a metal matrix. Examples of matrices in such composites include aluminium, magnesium and titanium.

The typical fiber includes carbon and silicon carbide. Metals are mainly reinforced to suit the needs of design. For example, the elastic stiffness and strength of metals can be increased, while large co-efficient of thermal expansion, and thermal and electrical conductivities of metals can be reduced by the addition of fibers such as silicon carbide.

(b) Ceramic Matrix Composites (CMCs)

Ceramic matrix composites have ceramic matrix such as alumina, calcium, aluminium silicate reinforced by silicon carbide. The advantages of CMC include high strength, hardness, high service temperature limits for ceramics, chemical inertness and low density. Naturally, resistant to high temperature, ceramic materials have a tendency to become brittle and to fracture. Composites successfully made with ceramic matrices are reinforced with silicon carbide fibers. These composites offer the same high temperature tolerance of super alloys but without such a high density. The brittle nature of ceramics makes composite fabrication difficult. Usually most CMC production procedures involve starting materials in powder form. There are four classes of ceramics matrices: glass (easy to fabricate because of low softening temperatures, include borosilicate and aluminium silicates), conventional ceramics (silicon carbide, silicon nitride, aluminium oxide and zirconium oxide are crystalline), cement and concreted carbon components.

(c) Polymer Matrix Composites (PMCs)

The most common advanced composites are polymer matrix composites. These composites consist of a polymer thermoplastic or thermosetting reinforced by fiber (natural carbon or boron). These materials can be fashioned into a variety of shapes and sizes. They provide great strength and stiffness along with resistance to corrosion. The reason for these being most common is their low cost, high strength and simple manufacturing principles. Due to the low density of the constituents, the polymer composites often show excellent specific properties.

C. Groundnut

Groundnut known as Arachis hypogeal belongs to the Leguminosae family. India is the second largest producer of nuts after China. In India, peanuts are the largest producer of maize and accounted for about 7.5 million tons in 2009-10. The complete seed of the groundnut is called the pod and the outer layer of the groundnut is called the shell. Brian George et. al. [20] investigated "the nutmeg. The average length of the nuts of the nutshell was found to be 38mm and 0.25mm diameter. The average rigidity of the nutshell is 1.06 g / den. In addition, the average fiber weight was 7.45% and the standard modulus was 25.3 g / den. Selected nutshells used in the current study. Clean and dried peanut shells are first washed with water to remove sand and other contaminants. The cleaned shells are chemically treated with a 10% solution of NaoH for 1 hour and then washed with distilled water. After that, the shells are dried at room temperature for 24 hours. The dried shells were low and the particles were filtered through a 600µm BS filter." The many authors for the preparation of material followed the similar procedure.

D. Chemical Composition of Groundnut Shell

Lignocelluloses fibres are made up of three main components: hemicelluloses, cellulose and lignin, which are known to present the most complex structure. Cellulose, a major component of fibres, is a semi crystalline polysaccharide composed of D-glucosidal bonds. A large number of hydroxyl groups in cellulose provide hydrophilic properties to natural fibres. Hemicellulose is tightly bound to cellulose fibrils, possibly by a hydrogen bond. It contains polysaccharides with a small molecular weight formed from hexoses, pentose and uranic acid residues. Lignin acts as a binding joint. Chemical compared to the composition of the selected species. The hemicellulose fibre content was found to be 18.7%, cellulose 35.7%, 30.2% lignin and Ash 5.9% Ash [9]. Table 1 compares the chemical composition of the nutshell with other important natural fibres. The hemi cellulose content of the nutshell is greater than that of Sisal. The lignin content of the shell stone fibre is much higher than that of coconut coir, bamboo, hemp, and kenaf as well as sisal fibres.

Table 1 Comparison of Chemical Composition of Groundnut shell with other natural fibers

	Cellulose	Hemicellulose	Lignin	Ash	Ref.
Species	wt.%	wt.%	wt.%	wt.%	
Coconut coir	47.7	25.9	17.8	0.8	[10]
Sisal	63-64	12	10-14	-	[10]
Groundnut shell	35.7	18.7	30.2	5.9	[9]
Rice husk	31.3	24.3	14.3	23.5	[11]
Bagasse	40-46	24.5-29	12.5-20	1.5-2.4	[12]
Hemp	70.2-74.4	17.9-22.4	3.7-5.7	-	[13]
Kenaf	31-39	21.5	15-19	-	[13]

The finite element analysis method is a general method of structural analysis in which the solution of a problem in continuum mechanics is approximated by the analysis of an assemblage of finite elements that are interconnected at a finite number of nodal points and represent the answer domain of the matter. The finite element method is now well accepted because of the most powerful general technique for the numerical solution of a spread of engineering problems. Applications range from the strain analysis of solids to the answer of acoustical phenomena, neutron physics, and fluid dynamic problems. Indeed the finite element method is now established as a general numerical method for the answer of partial differential equations subject to the known boundary and initial conditions.

The FE model plays an important role in the analysis in order to reduce the computational time and improve results. Minor details that are not affecting the solution should not be included in the FE model. Thus in the physical system, if symmetry in geometry, material properties, and loading is ignored and an only a representative portion is considered for analysis. Meshing also affects the better approximation of the solution. Mesh density improves a better approximation of the solution.

II. LITERATURE REVIEW

The composite material is suitable for use in structure where high weight strength and rigidity are required. Airplanes and spacecraft are common objects that are sensitive to weight when compact materials are expensive. In addition, a composite asset can be designed according to the required structures to obtain the necessary properties for the composite analysis of these structures is important. Many researchers have contributed their research to compound analysis by many organizations and continue to work on composite material, some of which are discussed here.

Onkar V Potadar and Ganesh S Kadam [13] investigated that “composite materials are now-a-days replacing the traditional materials because of its superior properties such as high tensile strength, low thermal expansion and high strength-to-weight ratio. Natural fiber composites such as groundnut shell polymer composites and coir composites have become more attractive due to their high specific strength, lightweight and biodegradability. This work attempts to study particulate natural fiber based epoxy composites. It is concerned with the preparation and testing of composite materials from groundnut shell fibers and coir fibers along with binder and epoxy resins. The groundnut shells are chemically washed, cleaned and then dried in sunlight. The dried shells are then grinded to particle sizes of 1 mm, 1.5 mm, 2 mm and the epoxy resins are added in 70:30 ratio by weight to the fibers in a 12 mm thick mould and different flat square-shaped composites are obtained. Specimens of different particle sizes are cut into standard dimensions as per ASTM for different mechanical and moisture absorption tests. The results thus obtained are relatively compared between groundnut shell and coir fibre composites to suggest suitable applications. In general, the coir fibre composites are found to be comparatively better than groundnut fiber composites particularly considering the mechanical properties."

An advanced book on mechanics of composite material by R. Jones [1] covers "applications of composite materials and micromechanical and macro-mechanical behaviour of lamina and laminates as well as the design of the composite structure. They have derived theoretical methods for the analysis of composite materials. An advanced book on mechanics of composite material by Autar K. Kaw covers applications of composite materials and micromechanical and macro-mechanical behaviour of lamina and laminates as well as the design of the composite structure. They have derived theoretical methods for the analysis of composite materials and explained PRIMAL Software for micro and macro mechanical analysis of lamina." A book on metal matrix composite by N. Chawla and K. K. Chawla has given the micromechanical analysis for the composite material.

A. Lakshumu Naidu et al. [14] investigated "the mechanical properties and development of a new set of natural fiber based polymer composites consisting of groundnut coir as reinforcement and epoxy resin. Experiments are carried out to study the effect of fiber length on mechanical behaviour of these epoxy based polymer composites. In the present work, coir composites are developed and their mechanical properties are evaluated. In addition, a step forwarded to use the agricultural waste technically and enhance the properties of several existing material, which can be more useful and can have advanced properties than the existing form. Finally, the composites were made by varying the percentage of groundnut shell from 0% to 6%. The specimens were tested before and after the heat treatment and data of hardness, values for all composites in both conditions were acquired from Rockwell hardness test. The results emphasized the increasing hardness value and reducing density of composites. The main objective is to compare the hardness and density of prepared composites from alloy from. In addition, comparison was made before and after the heat treatment. The detailed test results and observations are discussed sequentially in the paper."

Liang-Wu Cai, Shashidhar Patil [15] investigated "effects of randomness on band gap Formation in Models of Fiber-Reinforced Composite Panels Having "Quasirandom Fiber Arrangements", Journal of Vibration and Acoustics. Large-scale deterministic simulations are performed in order to observe the band gap formation in composite models having quasirandom fibre arrangements. Unidirectional fibre-reinforced composite panels are modelled in two-dimensional space with quasirandom fibre arrangements that can be qualified as "essentially regular with slight randomness." Different quasirandom fiber arrangements are computationally generated using the same control parameters. Statistical parameters are used to quantitatively describe the fiber arrangements. Subsequently, a series of arrangements is generated from each base line arrangement by scaling up the coordinates of fiber centers, while the fiber diameter remains unchanged in order to study the effects of fibre spacing. Simulation results are compared with the corresponding case of ideally regular fiber arrangement. The most interesting observation is that the slight randomness in the fiber arrangements enhances the band gap phenomenon by introducing a few secondary band gaps adjacent to the primary band gap. In summary, a pair of statistical parameters for describing random distribution of fibers has been defined. Large-scale deterministic simulations for the scattering of elastic SH waves by three sets of quasirandom fiber arrangements have been performed to observe the band gap formation when the fiber spacing varies. These fiber arrangements can be called as largely regular with slight randomness. Simulation results show that the primary band gap is almost identical to the band gap found in the corresponding ideal regular arrangement of fibers. The most interesting observation from the simulation results is that the slight randomness has broadened the band gap by introducing a number of secondary band gaps adjacent to the primary band gap. However, this observation is based on a limited set of three quasirandom fiber arrangements produced by the same control parameter. Due to the nature of randomness, more extensive simulations based on different base line configurations with the same control Parameter are needed in order to form a definitive conclusion."

Shiladitya Basu, Anthony M. Waas, Damodar R. Ambur [16] studied "Prediction of progressive failure in multidirectional composite laminated panels. A mechanism-based progressive failure analyses (PFA) approach is developed for fibre reinforced composite laminates. Each ply of the laminate is modelled as a nonlinear elastic degrading lamina in a state of plane stress according to Schapery theory (ST). In this theory, each lamina degrades as characterized through laboratory scale experiments. In the fiber direction, elastic behaviour prevails, however, in the present work, the phenomenon of fiber micro buckling, which is responsible for the sudden degradation of the axial lamina properties under compression, is explicitly accounted for by allowing the fiber rotation at a material point to be a variable in the problem. Experimental and numerical simulations that show that local fiber rotations in conjunction with a continuously degrading matrix are responsible for the onset of fiber micro buckling leading to kink banding motivate the latter. These features are built into a user defined material subroutine that is implemented through the commercial finite element (FE) software ABAQUS in conjunction with classical lamination theory (CLT) that considers a laminate as a collection of perfectly bonded lamina."

V. Tita, J. de Carvalho and J. Lirani [17] investigated "Theoretical and Experimental Dynamic Analysis of Fiber Reinforced Composite Beams. The composite materials are well known by their excellent combination of high structural stiffness and low weight. Their inherent anisotropy allows the designer to tailor the material in order to achieve the desired performance requirements. Thus, it is of fundamental importance to develop tools that allow the designer to obtain optimized designs considering the structural requirements, functional characteristics and restrictions imposed by the production process. Within these requirements, this work considers the dynamic behaviour of components manufactured from fibre reinforced composite materials."

To this end, some beams were made using the hand-lay-up process followed by molding struggling and heating. Experimental dynamic tests were administered using specimens with different fiber orientations and stacking sequences. From the results, the influence of the fiber orientations also because the stacking sequences on the natural frequencies and modal damping were investigated. In addition, these experiments were used to validate the theoretical model and the results obtained from the finite element analysis.

G. C. Onuegbu et al (2013) [18] investigated "the mechanical properties of polypropylene composites with ground nut husk powder at different particle sizes and found that the presence of ground nut husk improved the tensile strength, modulus, flexural strength and impact strength of the composites."

Behzad Kord (2011) [19] studied "the effect of calcium carbonate as mineral filler on the physical and mechanical properties of wood based composites and found that the mineral filler loading had significant effects on the mechanical properties of wood based composites."

Sanjay Kindo et. al. [21], an investigation has been administered to form use of coir, a natural fiber abundantly available in India. Natural fibres are not only strong and lightweight but relatively rock bottom. This work describes the event and characterization of a replacement set of natural fibre-based polymer composites consisting of coconut coir as reinforcement and epoxy as matrix material. The developed composites are characterized with reference to their mechanical characteristics. Experiments are administered to review the effect of fibre length on the mechanical behaviour of those epoxy-based polymer composites. Finally, the scanning microscope (SEM) of fractured surfaces has been done to review their surface morphology.

Merlin Barschke et. al. [22], investigated two-hybrid approaches to model is woven fibre reinforced materials were presented during this paper. One among these approaches was wont to obtain the fabric properties for a two-layered material, which may be applied to a 3-dimensional structure. To get the values of von Mises stress within the model conversion factors are calculated which relate the von Mises stress within the modelled material with the important occurring von Mises stress within the resin. Since the woven fibre model is predicted on the idea of a linear Young's modulus for the resin, nonlinear material properties are to be included within the analysis. The impact of the used simplifications is to be investigated. Additionally, it has to be investigated whether a more elaborated way of obtaining the typical material properties is often found, in order that all types of stresses are often related. The woven fibre approach is to be compared with real experiments on the discussed material to verify the validity of the approach.

M. Rajesh et. al. [23], investigated from the FEM Analysis, it is confirmed that there is an opportunity of reducing the strain concentration within the matrix and fiber interphase by increasing the fiber content. More stress deviation in the fiber, matrix and the interphase regions of the composite leads to changes of fiber de-bonding. Finite element method software simulation reveals that there is need to have certain assumptions for the perfect bonding and to define interphase properties. In the present method, the model is validated using some assumptions because natural fibers are anisotropy, porosity and therefore the interphase, whose volume will vary with different conditions and fiber arrangements. Hence, the obtained values are Predicted values.

A. Bensely et. al. [24] investigated "the mechanical properties of coir fibre composites. In the present work, coir composites are developed and their mechanical properties are evaluated. Scanning electron micrographs obtained from fractured surfaces were used for a qualitative evaluation of the interfacial properties of coir/epoxy and compared with glass fiber epoxy. These results indicate that coir can be used as a potential reinforcing material for making low load bearing thermoplastic composites."

The current review focuses on the continuation of coir fiber in compounding; an effort to take advantage of the benefits offered by renewable resources for the construction of composite bio composites. It is a challenge to build better facilities to improve the quality of life with better machine facilities. The current review also focuses on the use of coir fiber as filler in composite materials, extracted from coconut husks. The purpose of the present study is to take advantage of the benefits offered by renewable resources for building composite materials based on coir fibers.

A. Concluding Remarks

In the literature review, it is seen that composite material can be designed and manufactured according to required properties. The key material properties for common designing mechanics applications are strength and stiffness. The usual design criterion for the composite material is based on trying to align the fibres with the most critically loaded directions of mechanical components. Again, a critical percentage of volume fractions of matrix material and fiber are also considered while designing the composite material. It is vital to seek out elastic constants and other mechanical properties of an orthotropic (glass epoxy) composite lamina experimentally as repeatedly theoretical and finite element approach for these may not give true results.

III. METHODOLOGY/ EXPERIMENTATION

This work examines the mechanical properties of metal matrix composites based on groundnut shell fiber. Fiber-reinforced polymer composites have played a dominant role for a long time in a variety of applications for their high specific strength and modulus. The fiber that serves as reinforcement in reinforced plastics may be synthetic or natural. Past studies show that only synthetic fibers such as glass, carbon etc., have been used in fiber-reinforced plastics. Although glass and other synthetic fiber-reinforced plastics possess high specific strength, their fields of application are very limited because of their inherent higher cost of production. In this connection, an investigation has been carried out to make use of coir, a natural fiber abundantly available in India. Natural fibers are not only strong and lightweight but also relatively very cheap. The present work describes the mechanical properties and development of a new set of natural fiber based polymer composites consisting of groundnut coir as reinforcement and epoxy resin. Experiments are carried out to study the effect of fiber length on mechanical behaviour of these epoxy based polymer composites. In the present work, coir composites are developed and their mechanical properties are evaluated. In addition, a step forwarded to use the agricultural waste technically and enhance the properties of several existing material that can be more useful and can have advanced properties than the existing form.

Figure 1 Groundnut Shell and Coir Mixture

Specimen Making: Araldite solution of CY-230 with the hardener of HY-951 is used as epoxy (matrix) material and groundnut shell with coir fiber 50-50% by weight are used for the preparation of composite material. (Groundnut shell with coir fiber mixture) 30% and 70% (epoxy and araldite mix) used. Araldite solution of CY-230 with the hardener of HY-951 heated in oven, mixed with proper proportion, and poured in mold. After cooling, it will convert into solid and used as composite material model for testing.

Figure 2 Specimen

A. Tensile Test:

Groundnut shell & coir epoxy composite is carried out from mold after two days. It is kept on plane surface for four days so that it becomes hard that hard specimen is ready for testing. Finished specimen of composite is taken and its length and cross sectional area is measured. The marking of centre line along the length is done. From centre line fifty mm marking on both sides is done. Then that specimen is fixed in the universal testing machine. Initial length of specimen in the UTM is measured then gradually loaded to note deformation. The tensile testing of the samples was done in accordance with ASTM D638 standards. The samples were made in dumbbell shape and then placed in the UTM and the tensile strength was evaluated.

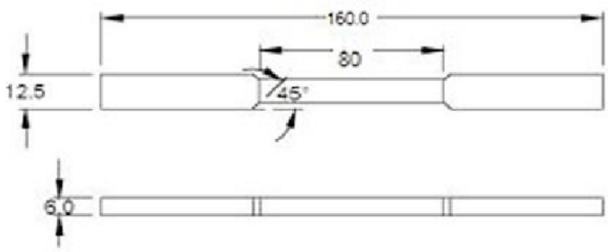

Figure 3 Standard specimen for tensile test

Figure 4 Actual Composite Specimen

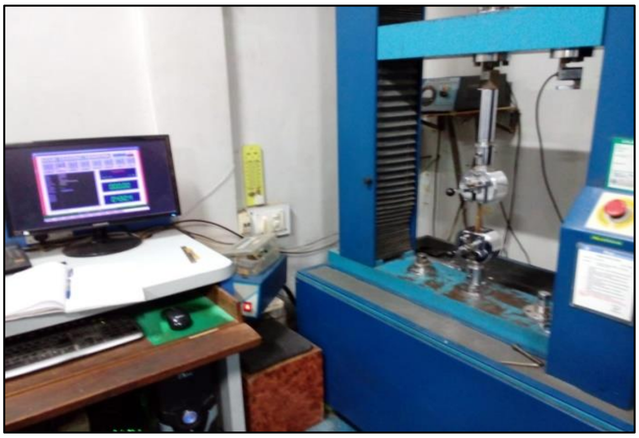

Figure 5 Tensile Test Setup

Table 2 Tensile Test Results

Width (mm)	**Thickness** (mm)	**C/s Area** (mm^2)	**Load** (N)	**Tensile Strength** (N/mm^2)
8.15	6.2	50.53	223	14

B. Flexural Test:

This test was carried out in accordance with an international method for determination of flexural test ASTM DS 654, the sample sheets were subjected to a central line load over a sample-supported span of 100mm. The sample roofing sheets were all tested in natural dry conditions and the load was measured using a proving ring load, which was gradually applied until failure of the specimen occurs.

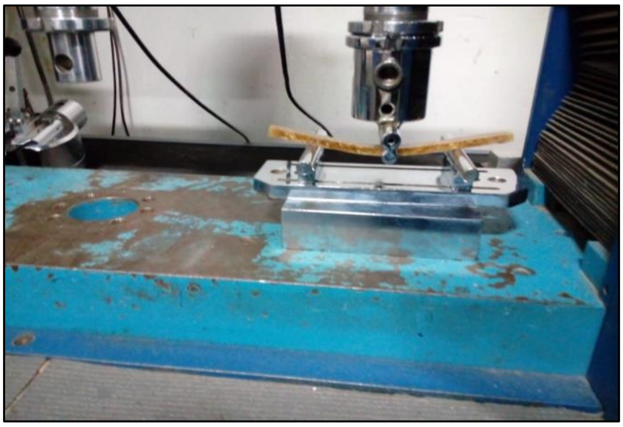

Figure 6 Flexural test setup

Table 3 Flexural Test Results

Width (mm)	**Thickness** (mm)	**Load** (N)	**Deflection** (mm)
12.45	5.8	50.47	9.2

C. Water Absorption Test:

The water absorption test was carried out based on ASTM D-570. The samples were cut, cleaned and weighed before immersion in distilled water at room temperature. The specimens were removed from the water after 24 hours and the surface was wiped off and weighed. The difference between the weight before and after immersion was noted. This procedure was repeated every 24 hours for 168 hours (7 days). The percentage water absorption 'W' was determined based on the expression:

$$W(\%) = \frac{w_f - w_o}{w_o} \times 100$$

Where, w_f and w_o are the final and initial weights of the samples after and before immersion respectively.

This result is contrary to expectation, as composites with fibre reinforcement, whether treated or un-treated, should exhibit higher water absorption due to the inherent hydrophilic nature of the filler. However, water absorption depends on several factors, namely the type of fibre, its loading and orientation, area of the exposed surface, interfacial adhesion, voids, and surface protection.

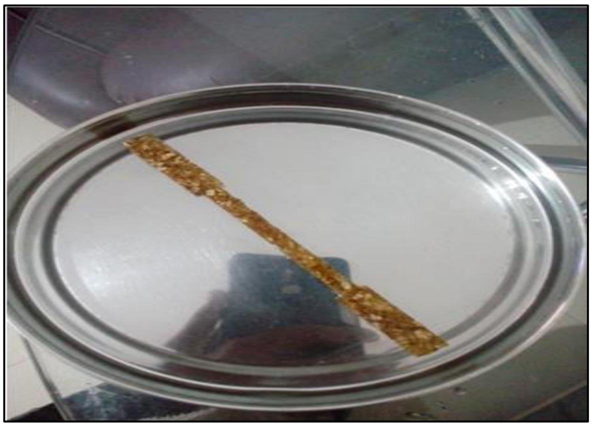

Figure 7 Moisture Absorption Test

Results of water absorption rate test are as follows:

Table 4 Moisture Absorption Test Result

Weight Of Specimen When Dry (gm.)	**Weight Of Specimen After Test** (gm.)	**Avg. Water Absorption Rate** (%)
10	12	20

D. Analysis of Composite Specimen using ANSYS:-

The FEA covers modelling a composite material with the dimensions and properties corresponding to specimen. Due to the symmetry in geometry, material properties, loading and degree of freedom constants, cross-section of the composite specimen and loading, symmetry is utilized in the FEA., only one fourth part of fibre and area required for that fibre sting out of total specimen area is considered and modelled. Modelling and analysis of composite material is done in the following sequence.

- Preferences: Analysis of specimen subjected to tensile loading.
- ANSYS Pre-processor: Pre-processor is divided in to following sub steps

1. Create the model geometry and meshing: Geometry is created by bottom-up approach. In first step, first key point is created at origin then circle of radius equal to fibre radius (1mm) is drawn with centre

point at first key point. Due to this circle, key points 2, 3, 4 and 5 are developed. Again, create key points 6, 7, and 8 required for matrix material according to the size of the matrix material. Positions of these key points are shown in table.

Table 5 Co-ordinates of key points for specimen -1

Key point	X-co-ordinate	Y-co-ordinate	Z-co-ordinate
1	0	0	0
2	1	0	0
3	0	1	0
4	-1	0	0
5	0	-1	0
6	4.3	0	0
7	4.3	4.3	0
8	0	4.3	0

After creating these key points straight lines are created between points 2-6, 6-7, 8-7, 3-8, 1-3 and 1-3. The lines 2, 4, 1 are deleted to create the required area. In next step for map meshing of model, the number of elements on all lines is fixed. Line number 8, 5, 9 divided into 7 elements, 9 elements are used for line number 10, 9. Line number 1 that is related to fibre string and to match with other part of model it is divided in to 10. Key points 4 and 5 which are not required these key points are deleted. In last step of creation of frontal area of model is to create the areas that areas are created by using lines.

2. Element Selection: For meshing of model two elements are used one 2D element for frontal area and area meshed is extruded by using 3D element.

1) Solid-PLANE 42 Element: PLANE42 is used for 2-D modelling of solid structures. The element can be used either as a plane element (plane stress or plane strain) or as an axes symmetric element. The element is defined by four nodes having two degrees of freedom at each node: translations in the nodal x and y directions. The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities. This element is used because in first step of modelling area is created for one fourth part of total model this area is meshed by using plane 42 elements. After meshing of this area it is reflected about three planes to get the front view of model. After creating this area it is extruded by using brick 8node 45 element.

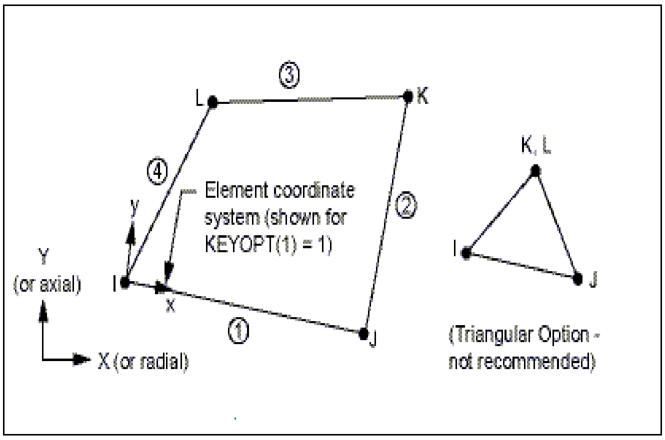

Figure 8 PLANE42 Geometry

Area is created by lines is the frontal area for one-fourth part of front area of matrix and fiber used in composite is formed. This one-fourth part is meshed then by using plane 42 elements. This element is used as dummy element for model. Thus, the meshing of front area of specimen is done as shown in figure.

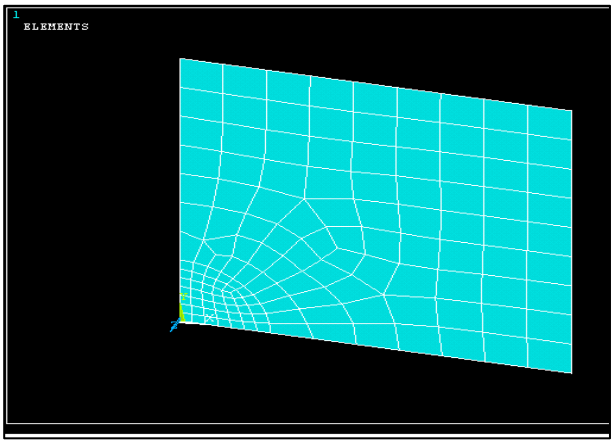

Figure 9 Meshing of C/S Area

2) Structural Solid Brick 8-node45 Element: SOLID45 is used for the 3-D modeling of solid structures. Eight nodes having three degrees of freedom at each node

define the element: translations in the nodal x, y, and z directions. The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities. The geometry, node locations, and the coordinate system for this element are shown in figure SOLID45 Geometry. Eight nodes and the orthotropic material properties define the element. Orthotropic material directions correspond to the element coordinate directions. Less CPU time is required for element stiffness formation and stress/strain calculations to achieve comparable accuracy to the FULL integration option. This element is used for getting the compatibility of nodes.

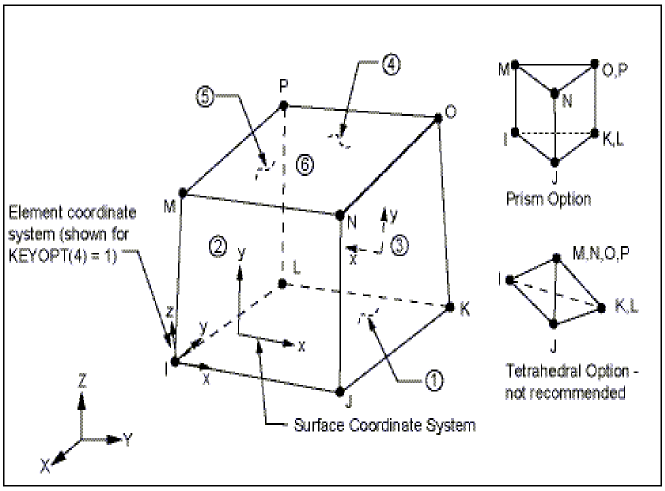

Figure 10 SOLID 45 Geometry

After meshing the front area for the model, the three dimensional model is created. First model for matrix material is created by selecting material 2. Front area is extruded with length of extrusion equal to 81 mm. while extruding the no elements taken along the length of extrusion is 81. Front area of fibre is also extruded with equal number of elements and by selecting third material. Thus, three dimensional finite element models are created as shown in figure 8.

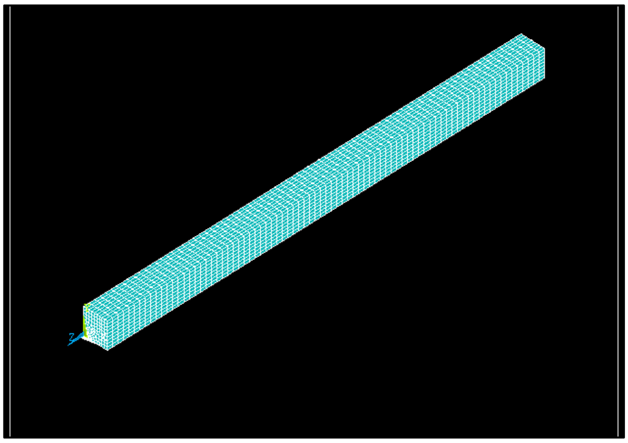

Figure 11 3D FE Model for Composite Specimen

- ANSYS Solution Processor:

In this step, full model with meshing is available boundary conditions are applied on model one by one. First conmen nodes, which are in contact with fibre and matrix material, are merged so that deformation of both materials is same. Next by selecting the areas 5, 11 and 8, 12 symmetry conditions is applied on these areas to get the symmetric conditions of the model.

To get the same deformation of all nods on the areas one and two of matrix and glass fibre all nodes on these two areas are coupled in Z direction and by selecting the areas on the other side all nodes are fixed so that one side of model is fixed. Coupled side of model is selected and load in terms of uniform pressure is applied on this area and solution for current load step file is obtained and results are recorded. After getting this results pressure load is changed by next pressure and second set of results is obtained. This process is repeated for five reading. Moreover, from this data modulus of elasticity is obtained for composite specimen number one.

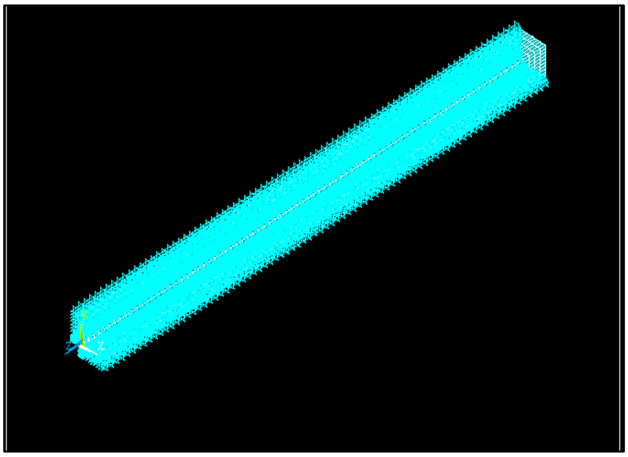

Figure 12 Symmetric boundary conditions on quarter model

IV. RESULTS AND DISCUSSION

Average Results obtained by mechanical testing and moisture absorption tests are pointed out in methodology by experimentation. In this section, we discussed results obtained through FEA analysis by using ANSYS and comparing it with experimental values.

ANSYS Results for Composite Specimens:

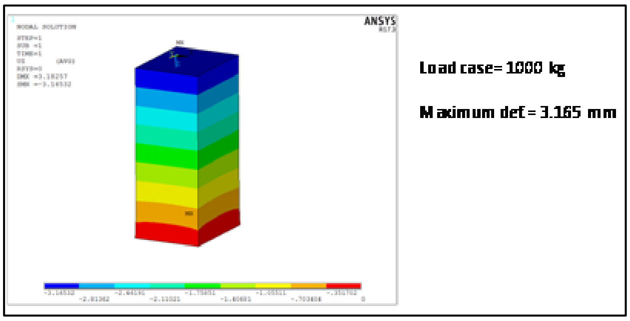

Figure 13 Deformation of specimen load 1000 kg

As shown above figure, when composite specimen loaded at 1000 kg and having length equal to 81 mm composite specimen deformed maximum by 3.165 mm.

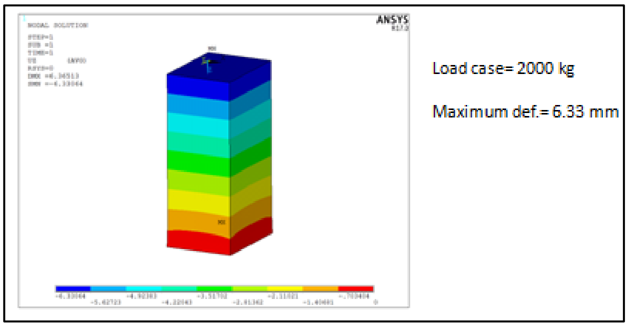

Figure 14 Deformation of specimen load 2000 kg

As shown above figure, when composite specimen loaded at 2000 kg and having length equal to 81 mm composite specimen deformed maximum by 6.33 mm.

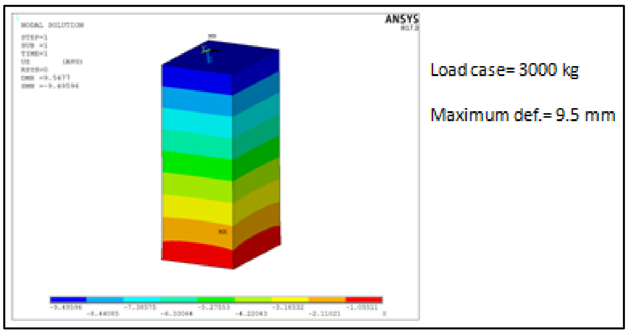

Figure 15 Deformation of specimen load 3000 kg

Further increasing load on the specimen, as shown above, figure, when composite specimen loaded at 3000 kg and having a length equal to 81 mm of composite specimen deformed maximum by 9.5 mm. As the load increases deformation also increases with increase in Modulus of elasticity.

For the next three specimens, the same procedure is to be repeated only the difference is in the preparation of the model. It is prepared according to the dimensions of specimens, the position of fiber and load is applied, and a modulus of elasticity is obtained.

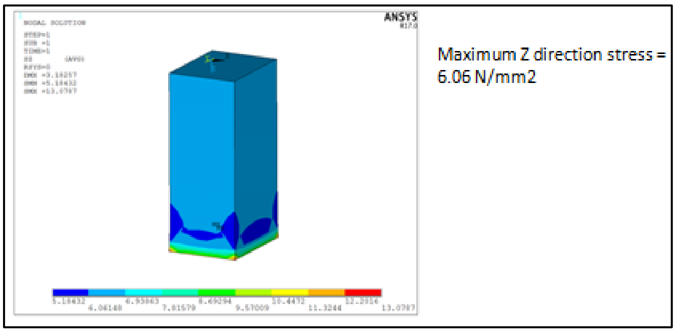

Figure 16 Stresses in specimen load 1000 kg

As shown above figure, when composite specimen loaded at 1000 kg and having length equal to 81 mm, maximum stress obtained in Z direction is 6.06 N/mm^2.

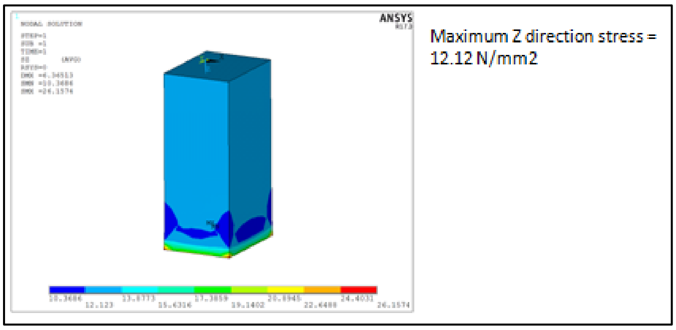

Figure 17 Stresses in specimen load 2000 kg

As shown above figure, when composite specimen loaded at 2000 kg and having length equal to 81 mm, maximum stress obtained in Z direction is 12.12 N/mm^2.

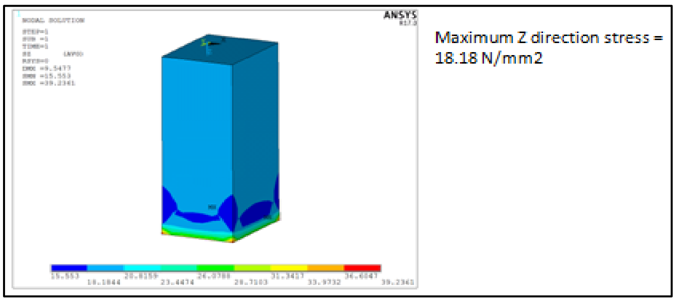

Figure 18 Stresses in specimen load 3000 kg

As shown above figure, when composite specimen loaded at 3000 kg and having length equal to 81 mm, maximum stress obtained in Z direction is 18.18 N/mm^2.

As the load increases deformation and stresses are also increases with increase in Modulus of elasticity.

All the results obtained from ANSYS tabulated as follows:

Length of specimen = 81mm

Table 6 ANSYS Results

Sr. No.	Load (kg)	Stress (N/mm2)	Deformation (mm)	Strain
1.	1000	6.06	3.165	0.1587
2.	2000	12.12	6.33	0.116
3.	3000	18.18	9.5	0.177
4.	4000	24.5	12.8	0.234
5.	5000	30.3	15.9	0.293

V. CONCLUSION

Experimental research leads to the following conclusions:

- 19.29 MPA tensile strength was found for a particulate grain size of 1 mm for groundnut fibre mix coir fibre composites.
- Higher flexural strength of 18.07MPA, in the particulate grain size of 1 mm.
- Moisture absorption capacity is 20% as specimen weight found 10 gram before test and 12 gram after test.
- Overall, coir mix ground nut shell composites are having equivalent strength as aluminium and nearby steel so can be replaced at steel and aluminium applications to some extent to get the advantage of low weight easy transportation and handling and no rusting issues as mechanical properties are concerned.

In this dissertation, a new composite mixture is tested for finding modulus of elasticity. Modulus of elasticity is found from experimental results and from the stress-strain graph and the average value of both methods is considered. The specimen's taken and average modulus of elasticity is considered from the results.

The epoxy model is prepared from the solution of CY-230 and HY-951 and it is tested in a universal testing machine. From these experimental results modulus of elasticity for matrix material is calculated. Also, modulus of elasticity is found from the stress-strain curve, and the mean of these two results is taken.

Then finite element analysis of composite specimen is made and results obtained are compared.
Modulus of elasticity for composite material specimens by experimental and finite element analysis is compared as shown in table 7.

Table 7 Comparative Table of Modulus of Elasticity

Material	**L mm**	**C/s Area mm^2**	**% Vol. fraction of fibre**	**% Vol. fraction of matrix**	**E1 N/mm^2**	**E2 N/mm^2**
Composite specimen	81	1496	30	70	1640	1503

Where, E1 and E2 are Modulus of Elasticity of experimental and FEM analysis respectively.

- Percentage error in modulus of elasticity measured by the experimental method as compared to calculated by ANSYS is 9.2% it is because of error in experimentations.

Attempts have been made to fabricate a composite material made of groundnut shell and coir fiber and epoxy material. Stress-strain curves for composite materials have been found out. The specimen has been tested in U.T.M. and the stress-strain curve for the specimen is plotted. Modulus of elasticity for composite specimen found experimentally and by FEA. Result analysis of composite specimen is made by considering experimental values of modulus of elasticity and from ANSYS results. The stress-strain curve is drawn from experimental results to find the modulus of elasticity, by using the micromechanics approach. From that, it is observed that there is a slight difference because of the following reasons.

1. In experimental analysis modulus of elasticity may change from fiber to fiber.
2. Infinite element analysis by using ANSYS plane stress condition assumed but the thickness of composite specimens is slightly more and axis symmetry is considered but specimens are not exactly symmetric.

From experimental data and stress-strain diagram, it is seen that composite specimen behaves elastically up to point of failure and is subjected to brittle fracture.

The fibers, matrix, and the composite material when loaded in tension are very much sensitive to strain rate and this is the reason for the deviation between ANSYS and experimental values.

The fiber volume fractions of the specimens are near about 30 %. This work is restricted up to the determination of tensile properties for this composite material.

VI. FUTURE SCOPE

In this dissertation, we have analysed the mechanical behaviour of composite material experimentally and by finite element analysis. Some errors may be present in this analysis. Only rectangular sections are used for the analysis and modulus of elasticity for these sections are found, one can use other different sections, and modulus of elasticity can be found for different sections.

This can be done by macro mechanical approach also rather we have done micro mechanical way. Also one can use other different mechanics of materials approaches such as self-consistent models, various techniques using energy-bonding principles, exact solutions, statistical approaches, semi-empirical approaches.

The modulus of elasticity can also be determined by compression testing. The properties can also be checked by mounting strain gauge on the specimen to be tested in U.T.M. We can also find out stiffness coefficients experimentally by changing the orientation of fibers.

An interesting approach to more realistic fiber-matrix interaction can be done by the contiguity approach.

The Hal pin-Tsai Equations developed by Hal pin and Tsai based on an interpolation procedure which is an approximate representation of more complicated micromechanics results. It is simple so, it can readily be used in the design process. Also, it enables generalization of usually limited, although more exact, micromechanics results.

To get the complete design of composite material other properties are also important the analysis of these properties can be done by using different methods.

VII. REFERENCES

[1]. Liang M. Jones “Mechanics of Composite Materials”, Taylor and Francis ltd. second edition 1999
[2]. Banu ki, “Mechanics of Composite Materials”. CRC press New York 1997.
[3]. Damodar, “Metal Matrix Composite”, Springer publication, New York, first edition 2006.
[4]. Tita, “Investigation of Fracture in Transparent Glass Fiber Reinforced Polymer Composites Using Photo elasticity”, ASME Journal of Engineering Materials and Technology January 2004, Vol. 126
[5]. Hubertus, “Material Characterization of Glass, Glass, and Hybrid-Fiber SCRIMP Panels”, Contractor Report for Sandia National Laboratories
[6]. Josef, “Durability-Based Design Criteria for a Chopped-Glass-Fiber Automotive Structural Composite” ORNL/TM-1999/182
[7]. T. Y. Kam, C. H. Lin. “Identification of Material Constants of Composite Laminates Using Measured Strains” ASME Journal of Engineering Materials and Technology OCTOBER 2000, Vol. 122’ 425.
[8]. Dr. Roberto Lopez-Anido, Mr. Fadi W. El-Chiti, Dr. Lech Muszyñski, and Dr. Habib J. Dagher “Composite Material Testing Using a 3-D Digital Image Correlation System” COMPOSITES 2004 Convention and Trade Show American Composites Manufacturers Association October 6-8, 2004
[9]. Ghassan N. Fayad, Habib J. Dagher, Roberto Lopez-Anido “Probabilistic Finite Element Analysis of ASTM D3039 Tension Test for Marine Grade Polymer Matrix Composites” Advanced Engineered Wood Composites Center University of Maine, Orono, ME 04469.
[10]. X. Q. Peng, J. Cao, “Numerical Determination of Mechanical Elastic Constants of Textile Composites” 15th Annual Technical Conference of the American Society for Composite.
[11]. Brajabandhu Pradhan Saroja Kanta Panda, “Effect of Material Anisotropy and Curing Stresses on Interface Delamination Propagation Characteristics in Multiply Laminated FRP Composites” ASME Journal of Engineering Materials and Technology JULY 2006, Vol. 128 / 383.
[12]. L.E. Govaert, R.J.M. Smit, T. Peijsand H.E.H. Meijer, “A micromechanical approach to time-

dependent failure in composite systems" Eindhoven University of Technology, materials Technology

[13]. Onkar V Potadar and Ganesh S Kadam "Preparation and Testing of Composites using Waste Groundnut Shells and Coir Fibers", rocedia Manufacturing 20 (2017) 91-96.

[14]. A. Lakshumu Naidu, B. Sudarshan, K. Hari Krishna, "Study On Mechanical Behavior Of Groundnut Shell Fiber Reinforced Polymer Metal Matrix Composites", International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 2, February- 2013 ISSN: 2278-0181

[15]. Liang-Wu CAI, Shashidhar Patil, "Effects of Randomness on Band Gap Formation in Models of Fiber-Reinforced Composite Panels Having Quasirandom Fiber Arrangements" Journal of Vibration Acoustic. Oct 2007, Volume 129 (5): 663-671

[16]. Shiladitya Basu, Anthony M. Waas, Damodar R. Ambur, "Progressive Failure Modeling of Laminates incorporating Material and Geometric Nonlinearities", AIAA 2006-1642

[17]. V. Tita, J. de Carvalho, J. Lirani, "Theoretical and experimental dynamic analysis of fiber reinforced composite beams", Journal of the Brazilian Society of Mechanical Sciences and Engineering, vol.25 no.3, July/Sept. 2003.

[18]. G. C. Onuegbu, S. C. Nwanonenyi, M. U. Obidiegwu, "The Effect of Pulverized Ground Nut Husk on Some Mechanical Properties of Polypropylene Composites", International Journal of Engineering Science Invention, Vol.2 (6), pp.79-83, 2013.

[19]. Behzad Kord, "Effect of calcium carbonate as mineral filler on the physical and mechanical properties of wood based composites", World Applied Sciences Journal 2011 Vol.13 No.1 pp.129-132.

[20]. B. R. George, A. Bockarie, N. Bieak, A. Evazynajad, A. Kar, S. Veluswamy, and H. McBride, "The Ninth Annual Conference on Recycling of Fibrous Textile and Carpet Waste", 2004.

[21]. Sanjay Kindo, Amar Patnaik, S. Biswas, "Effect of fiber length on mechanical behavior of coir fiber reinforced epoxy composites", Fibers and Polymers volume 12, pages73–78 (2011).

[22]. Merlin Barschke, David Uribe, Oscar E. Ruiz, Jens Jensen and Carlos Lopez, "Finite Element Modeling of Composite Materials using Kinematic Constraints" ISSN 1794–9165, vol.5, no.10, pg-133-153(2009).

[23]. M. Rajesh, T. Srinag, P. Phani Prasanthi, K. Venkataraovenkatrao, "Finite Element Analysis of Coir/Banana Fiber Reinforced Composite material", International Journal of Advanced Research in Mechanical Engineering & Technology (IJARMET), ISSN : 2454-4736, Vol. 2, Issue 4 (Oct. - Dec. 2016).

[24]. S. Harisha, D. Peter Michael, A. Bensely, D. MohanLal, A. Rajadurai, "Mechanical property evaluation of natural fiber coir composite", ELSEVIER, Volume 60, Issue 1, January 2009, Pages 44-49.

Cite this article as :

Anand Harinarayan Pagar, Prof. (Dr.) S. R. Suryawanshi, "Finite Element Analysis of Groundnut Shell and Coir Fiber Mix Epoxy Composite Moulding and Testing",International Journal of Scientific Research in Mechanical and Materials Engineering (IJSRMME), ISSN : 2457-0435, Volume 5 Issue 2, pp. 01-17, March-April 2021.

URL : https://ijsrmme.com/IJSRMME21521