Groundnut Shell and Coir Fibre Mix Epoxy Composite Moulding and Testing

Mr. Anand Harinarayan Pagar, Department of Mechanical Engineering, MET's Institute of Engineering, Nashik, Maharashtra, India. anand.pagar@gmail.com

Dr. S. R. Suryawanshi, Assistant Professor, Department of Mechanical Engineering, MET's Institute of Engineering, Nashik, Maharashtra, India. shubhamsuryawanshi255@gmail.com

Abstract- **Current work has been done, to test the strength of groundnut shell & Coir fibre polymer composites and study the mechanical properties of composites. Current work reports the use of groundnut & Coir fibres, as reinforcement in the polymer matrix. This review focuses on providing information to improve on-going research in this area. The potential for surface chemical conversion of groundnut & Coir fibres 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 fibres. The influence of the source of the groundnut shell & Coir fibre is reported on organic material. Several natural compounds of fibre complement the properties of fibreglass 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 fibre seems bright. The production of composite materials is therefore planned by mixing coir fibre and earth shell in epoxy and Araldite and testing its strength at UTM.**

Keywords — Groundnut Shell, Green Composites, Matrix, Coir Fibres, and Mechanical Testing.

I. INTRODUCTION

The word composite within the term material signifies that two or more materials are combined on a macroscopic scale to make a useful third material. The key is a great material experiment in which parts can be seen with the naked eye. Different materials can be assembled to a lesser extent, such as metal composites, but as a result, for all functional purposes, they are the same macroscopically, that is, the eyes and work together cannot separate the parts.

In composite objects, two or more different elements are grouped but they always point specifically to the combination. The most common example, perhaps, fibreglass/carbon fibre/coir fibre/sisal fibre/groundnut shell; one or two of these are mixed with a polymeric resin. If we cut the fibre and after proper facial adjustment, when we look at the material, the strands and polymer resin can be easily separated. This is not the same as making an alloy by mixing two different elements when each part is not visible. There are many composite materials and although we may know some, there are many more from nature, reinforced concrete mixed with concrete which is a mixture of rock and cement particles, pneumatic tires rubber wires lined with rubber, many cheap plastic moulds (polyurethane resin) ceramics such as chalk & talc on the outer parts of the metal used in the space system (titanium steel reinforced with SiC ceramic fibres), and in cars, such as piston engines (aluminium-filled aluminium alloys) and disc brakes (aluminium alloys loaded with resistant SiC particles). Regardless of how it is constructed, the two [or more] elements that make up a compound are easily separated when the material is split or broken [1].

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 composites can 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).

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. Classification of Composite Material

Composites are separated by reinforcing geometry - particulate, flake and string [2].

a) Particulate composites contain particles embedded in matrices such as alloys and ceramics. It is usually isotropic because particles are added randomly. Particulate compounds have benefits such as improved strength, increased operating temperature and oxidation resistance, etc. Typical examples include the use of aluminium particles in a mortar, silicon carbide particles in aluminium, and gravel, sand, and cement to make concrete.

b) Flake composites contain clear matric reinforcement. Common materials are flake glass, mica, aluminium, and silver. Flake composites offer advantages such as a very high flight / high modulus, and low cost. However, flakes cannot be easily directed and there are only a limited number of building materials that can be used.

c) Fibre compositions consist of a matrix reinforced with short (non-breaking) or long (continuous) fibres. The fibres are usually anisotropic and the specimens include glass and aramids. Examples of matrices are resins such as epoxy, metals such as aluminium, and clay such as calcium-alumina silicate. The basic units for continuous fibre matrix integration are unidirectional or fibre laminas. Laminas are placed on top of each other at different angles to form a multidirectional laminate [2].

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. [11] investigated “the nutmeg. The average length of the nuts of the nutshell was found to be 38mm and 0.25mm in diameter. The average rigidity of the nutshell is 1.06 g / den. Also, the average fibre 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 a 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 hemicellulose 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 [14].

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

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

II. LITERATURE REVIEW

The composite material is suitable for use in the structure where high weight strength and rigidity are required. Aeroplanes and spacecraft are common objects that are sensitive to weight when compact materials are expensive. Also, 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 a compound analysis by many organizations and continue to work on composite material, some of which are discussed here.

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 [2] 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.

Onkar V. Potadar and Ganesh S. Kadam [4] investigated that "composite materials are nowadays replacing the traditional materials because of their superior properties such as high tensile strength, low thermal expansion and high strength-to-weight ratio. Natural fibre 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 fibre-based epoxy composites. It is concerned with the preparation and testing of composite materials from groundnut shell fibres and coir fibres along with binder and epoxy resins. The groundnut shells are chemically washed, cleaned and then dried in sunlight. The dried shells are then ground to particle sizes of 1 mm, 1.5 mm, 2 mm and the epoxy resins are added in a 70:30 ratio by weight to the fibres 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 fibre composites particularly considering the mechanical properties."

A. Lakshumu Naidu et al. [5] investigated "the mechanical properties and development of a new set of natural fibre based polymer composites consisting of groundnut coir as reinforcement and epoxy resin. Experiments are carried out to study the effect of fibre length on the mechanical behaviour of these epoxy-based polymer composites. In the present work, coir composites are developed and their mechanical properties are evaluated. Also, 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 the Rockwell hardness test. The results emphasized the increasing hardness value and reducing the density of composites. The main objective is to compare the hardness and density of prepared composites from alloy. Also, the 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 [6] investigated "effects of randomness on bandgap Formation in Models of Fibre-Reinforced Composite Panels Having "Quasirandom Fibre Arrangements", Journal of Vibration and Acoustics. Large-scale deterministic simulations are performed to observe the bandgap 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 fibre arrangements are computationally generated using the same control parameters. Statistical parameters are used to quantitatively describe the fibre arrangements. Subsequently, a series of arrangements are generated from each baseline arrangement by scaling up the coordinates of fibre centres, while the fibre diameter remains unchanged to study the effects of fibre spacing. Simulation results are compared with the corresponding case of ideally regular fibre arrangement. The most interesting observation is that the slight randomness in the fibre arrangements enhances the bandgap phenomenon by introducing a few secondary band gaps adjacent to the primary bandgap. In summary, a pair of statistical parameters for describing the random distribution of fibres has been defined. Large-scale deterministic simulations for the scattering of elastic SH waves by three sets of quasirandom fibre arrangements have been performed to observe the bandgap formation when the fibre spacing varies. These fibre arrangements can be called largely regular with slight randomness. Simulation results show that the primary bandgap is almost identical to the bandgap found in the corresponding ideal regular

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arrangement of fibres. The most interesting observation from the simulation results is that the slight randomness has broadened the bandgap by introducing several secondary band gaps adjacent to the primary bandgap. However, this observation is based on a limited set of three quasirandom fibre arrangements produced by the same control parameter. Due to the nature of randomness, more extensive simulations based on different baseline configurations with the same control Parameter are needed to form a definitive conclusion."

Shiladitya Basu, Anthony M. Waas, Damodar R. Ambur [7] 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 by laboratory-scale experiments. In the fibre direction, elastic behaviour prevails, however, in the present work, the phenomenon of fibre micro buckling, which is responsible for the sudden degradation of the axial lamina properties under compression, is explicitly accounted for by allowing the fibre rotation at a material point to be a variable in the problem. Experimental and numerical simulations that show that local fibre rotations in conjunction with a continuously degrading matrix are responsible for the onset of fibre 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 a perfectly bonded lamina."

V. Tita, J. de Carvalho and J. Lirani [8] investigated "Theoretical and Experimental Dynamic Analysis of Fibre Reinforced Composite Beams. The composite materials are well known for their excellent combination of high structural stiffness and low weight. Their inherent anisotropy allows the designer to tailor the material 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."

G. C. Onuegbu et. al. (2013) [9] investigated "the mechanical properties of polypropylene composites with groundnut husk powder at different particle sizes and found that the presence of groundnut husk improved the tensile strength, modulus, flexural strength and impact strength of the composites."

Behzad Kord (2011) [10] 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."

The current review focuses on the continuation of coir fibre 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 fibre 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 fibres.

III. METHODOLOGY

A. *Manufacturing of Groundnut Shell & Coir Mixture*

50-50% Groundnut shell and Coir crushed to 1mm size.

Fig. 1 Groundnut Shell and Coir Mixture

B. *Epoxy Mixture Preparation*

Araldite solution of CY-230 with the hardener of HY-951 is used as epoxy (matrix) material, which is available in liquid form. These two constituents are heated in an oven and mixed with proper proportion. After cooling, it will be converted in to solid and that solid is used as an epoxy model for testing.

Fig. 2 Epoxy (70%) and Composite Mixture (30%)

C. *Mould Preparation for Epoxy*

A transparent acrylic sheet is used for mould preparation. An acrylic sheet of 2mm thickness is selected. The plates are cut from the sheet according to mould size. Plates are

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cut by some tolerance is kept for finishing. All sides of the plates are finished and made perpendicular. All sheets are joined by using the feviquick and the box is made with one open side. After tightening the plates the mould is well cleaned. The wax or clay material is pasted in each joint to avoid leakage. One side of the mould is kept open to pour the mixture. Thus mould is prepared & inspected carefully for the leak.

D. Epoxy Solution Preparation

Araldite solution of CY-230 with the hardener of HY-951 is separately heated in the oven for about 2 hours at a rate of 70 to 100 degree to remove moisture and air bubble. The heated solution is cooled slowly at room temperature. The hardener HY-951 is added slowly to CY-230 & HY-951 mixture by weight is 100: 10. During mixing, the mixture is stirred continuously in one direction for proper & thorough mixing. The mixture is stirred for about 20min. now it is ready for pouring into a mould. The reaction between Araldite & hardener is exothermic. Simultaneously acrylic mould is chemically cleaned. Then this mixture is poured in to mould very cautiously to avoid the formation of air bubbles. The mould is filled with the mixture. At this position, the mould is kept for curing at room temperature for 24 hours. After that solution of hardener and resin becomes solid that solid formed can be easily removed from the mould. Thus the solid model of epoxy or matrix material is prepared. That model is kept on a plane surface for four days to become hard. After four days it is taken for the test.

E. Specimen Making

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

Fig. 3 Specimen

Table II Ratio of Matrix to Composite Mixture

Specimen	**Matrix**	**Composite (Grain Size)**
1	70%	30% (1mm)
2	70%	30% (1.5mm)
3	70%	30% (2mm)

F. Composite Material Specimen Tensile Testing

Groundnut shell & coir epoxy composite is carried out from mould after two days. It is kept on the plane surface for four days so that it becomes hard that the hard specimen is ready for testing. A finished specimen of the composite is taken and its length and the cross sectional area is measured. The marking of the centre line along the length is done. From the centre line, a fifty mm marking on both sides is done. Then that specimen is fixed in the universal testing machine. The initial length of the specimen in the Universal testing machine is measured then gradually loaded to note deformation.

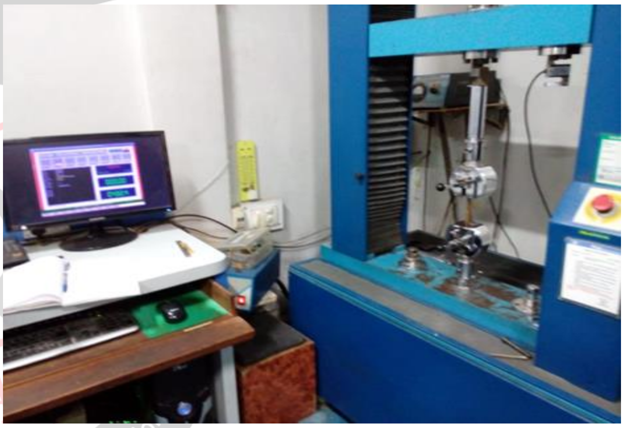

Fig.4 Tensile Test Setup

G. Flexural Test

A standard specimen size of 165x12x6mm is tested on UTM to find flexural strength. (ASTM D7264)

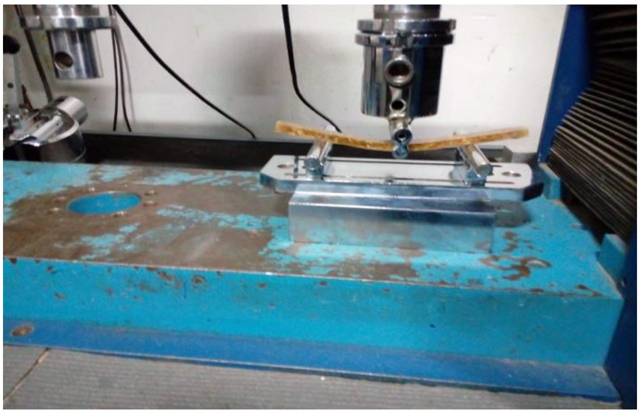

Fig.5 Flexural Test Setup

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H. Moisture Absorption Test:

Moisture Absorption Test is performed based on ASTM D-570. Samples were cut, cleaned and measured before immersion in refined water at room temperature. Specimens were removed from the water after 24 hours and wiped above the surface by weight. Differences between weight before and after immersion were noted. This process was repeated every 24 hours for 168 hours (7 days).

This effect contradicts expectations, as fibre-reinforced compounds, whether treated or untreated, should exhibit high water absorption due to the hydrophilic filling condition. However, water absorption depends on some factors, namely the type of fibre, its loading and shape, the location indicated, the adhesion of the joints, the voids, and the earth's protection.

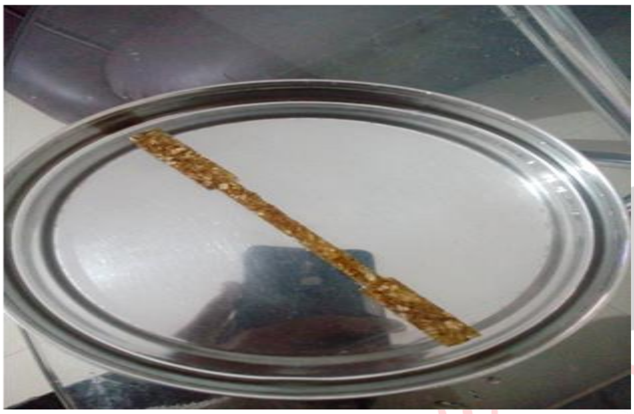

Fig. 6 Moisture Absorption Test

IV. RESULTS AND DISCUSSION

Results obtained by mechanical testing and moisture absorption tests are as follows:

The graphs in fig.7 show the results of mechanical tests and the moisture content of the groundnut composites, while Fig.8 below shows the same with coir fibre composites. Similar trends are observed in both cases, the combination of nuts and coir fibre composites is considered the durability of the groundnut composites; it is evident that the strength of the material decreases by increasing the grain size of the particle groundnut fibre. However, with the flexibility of the groundnut compounds, it is evident that flexural strength begins to decrease with an increase in grain size from 1 to 1.5 mm and then increases with an increase in grain size from 1.5 to 2 mm. Considering the absorption of moisture from the nut-formed mixture, it is evident that the moisture absorption rate continues to increase with the increase in grain size. Therefore, the best the compacted nut compound is mainly composed of a 1 mm diameter compound of the fibre as it provides very high mechanical properties with very strong strength and high flexibility, while the very low moisture absorption needs to stay on the lower side of the shelf life.

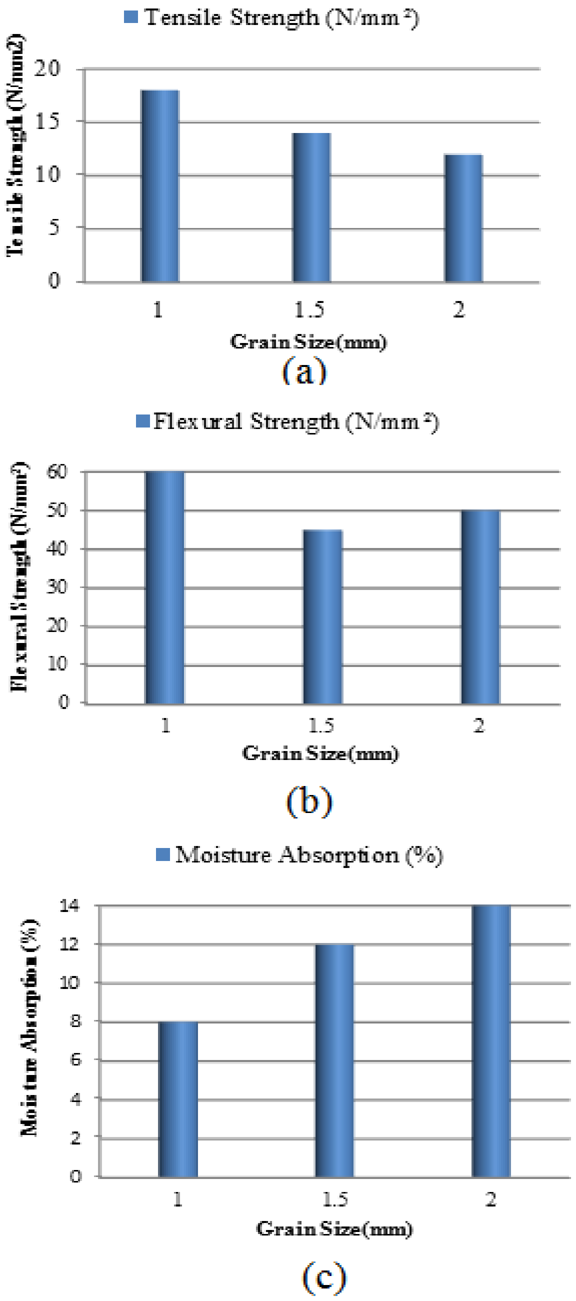

Fig. 7 Results for groundnut fibre composites: Grain size vs. (a) Tensile strength, (b) Flexural strength, and (c) Moisture absorption

Continuing to discuss the strength of coir fibre composites, it is evident that tensile strength decreases with increasing grain size of particle coir fibre. However, with the flexibility of coir fibre composites, it is evident that the flexural strength first decreases significantly with an increase in grain size from 1 to 1.5 mm and then continues to increase noticeably with an increase in grain size from 1.5 to 2 mm. Considering the moisture absorption of coir fibre composites, it is evident that the moisture absorption rate continues to increase with the increasing grain size of particle coir fibre. So the best of composites made of coir fibre composites consists of composites with a size of 1 mm of particle coir fibre, as it provides high mechanical properties with very strong strength and high flexural strength, while very low moisture absorption.

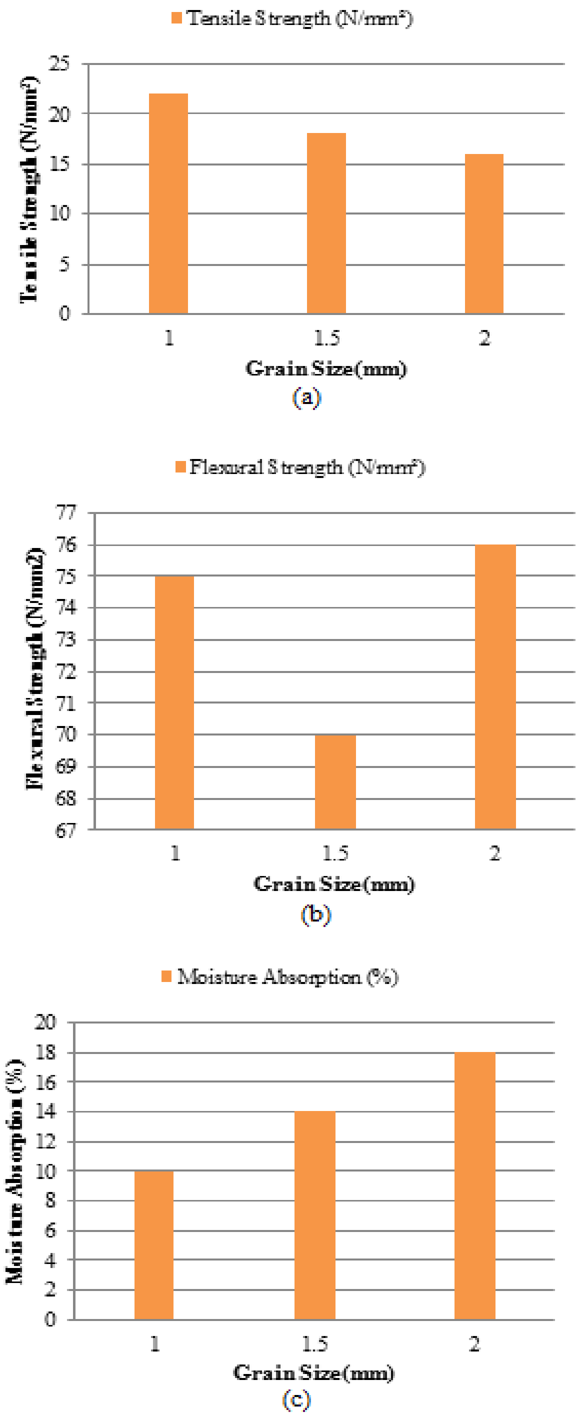

Fig. 8 Results for coir fibre composites: Grain size vs. (a) Tensile strength, (b) Flexural strength, and (c) Moisture absorption

V. CONCLUSION

Experimental research leads to the following conclusions:

•Both the grain size and the type of fibre greatly affect the mechanical properties and the moisture absorption capacity of the compounds involved.

•The strongest strength found in the size of 1 mm grains in both, a combination of nuts and coir fibre compounds; but coir fibre composites were much stronger compared to fibre nut composites.

•When it comes to high flexibility, and the thickness of the 1 mm particles provide the same for both, the combination of nuts and coir fibre compounds; and coir fibre composites were relatively comparable in strength to peanut fibre.

•Considering the moisture absorption capacity, the particle size of the particle doubled 1 mm to provide the equivalent of the lowest of both, a mixture of peanuts and coir fibre composites; but the synthetic nut structure produced a lower moisture absorption capacity than the coir fibre composites making it more suitable.

•Overall, coir fibre composites are much better compared to groundnut composites depending on the mechanical properties.

•Overall, the combination of coir mix groundnut shell has the same strength as aluminium and adjacent steel so alloys and aluminium alloys can be replaced to some extent to facilitate low weight for easy transport and handling and no rust problems as machinery structures are affected.

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