Journal of Mines, Metals and Fuels, *71(12D): 194-201; 2023. DOI: 10.18311/jmmf/2023/47988*

Print ISSN : 0022-2755

Journal of Mines, Metals and Fuels

Contents available at: *www.informaticsjournals.com/index.php/jmmf*

Impact Analysis and Mechanical Characterization of Sandwich Composites

Pranav S. Srirampur[1], H. Doddabasayyaswamy[1], K. Sagar[1]*, B. S. Sridhar[1] and A. R. Shashikala[2]

[1]Department of IEM, MS Ramaiah Institute of Technology, Bengaluru – 560054, Karnataka, India; sridharbs@msrit.edu

[2]Department of Chemistry, Presidency University, Bengaluru – 560064, Karnataka, India

Abstract

A waterproof roofing laminate comprises an Areca fibre mat with a coconut coir sandwiched layer, the fibre acts as with the fibre laid on top as an insulating layer and a top layer that visibly reflects radiant energy such as light, infrared, sunlight and ultraviolet light. Growing concerns about global warming and the depletion of oil reserves have led scientists to focus more on using natural fibres such as bagasse, coir, sisal, jute, etc. Natural Fibre Reinforcement in composites has recently attracted attention due to its low cost, ready availability, low density[1], acceptable specific parameters, easy specifications, enhanced energy, and recyclable nature. There, is an impact of various elements like fibre diameter, fibre content, density, fibre size, the geometry of fibre and coupling agents towards the automatic properties, and thermal properties. Natural fibres and natural fibre composites can be used in engineering applications because of their environmental suitability and economical nature. The combination of fibres is an excellent way to improve the mechanical, and thermal stability of Epoxy Compounds reinforced with Natural Fibre[2]. Coconut Fibres are environmentally safe, and pellucid with a well-put-in-order structure, towering tensile strength than glass, superior elasticity, and magnificent resilience.

Keywords: *Areca Mat, Coconut Coir, Epoxy Resin and Hardener, Mold*

1.0 Introduction

A roof is a structure's top covering that protects against wind, rain, snow, sunlight and other weather conditions. It encompasses all the raw materials buildings required to bolster the structure of a panel. Roofing is the material for a covering. Roof tiles are significant for roofing in housing construction. Roofing sheets are made of steel, aluminium alloys and galvanised steel. Bakedclay moulds are used to create clay roof tiles, how long and at what temperature the roofing tiles are heated determines the density of the tiles. Roof tiles come in various colours, including white, yellow, orange, and brown. Like conservative concrete, concrete tiles are created by pressing a mixture of sand, cement, and extreme heat and pressure applied to water. The concrete's lustrous exterior can be either left painted or unpainted to give it a better distinguishing and personified look. Three different designs of concrete tiles are available: flat, which has no curves; low profile, which has a modest curve; and high profile, which has a huge curvature. They are durable and non-combustible. Coir is a herbal fibre taken out from the outer husk of a coconut and used in different applications such as doormats, brooms and pallets[3]. Coir, the thread-like structure rests between the gritty intramural shell and the outward layer. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. This organic product is derived from the coconut tree. Coconut coir

**Author for correspondence*

has been used to manufacture ropes, rugs, brushes, doormats, mattress stuffing, and cloth owing to its robust and fibrous nature. Solitary fibrous material cubicles are slender and hollow filled with cellulose primary-based concentrated. They are off-colour although jejune however as a wrapper of lignin has been produced on their enclosures, they congeal and turn yellow. Coir fibre is one of the few natural fibres which is resistant to saltwater damage and is relatively waterproof. Two types of Fibre are taken in coconut coir White coir, and Brown coir[4]. The habitual chomping nuts, also familiar to as betel nuts or Supari are generated from the Areca Nut palm. Prime lands preparing the Areca crop are as follows Karnataka (40%), Kerala (25%), Assam (20%) etc. It belongs to the family of Palmaceae. About 100 fruits per Areca tree are produced annually, and bamboo poles are used to separate the fruits from the trees[5]. The length of the Areca nut is about 2.5cm the nut's base measures 2-3 cm in width. The Areca nut has a conical shape. Areca seeds are extremely tough, taste astringent and acrid, and have a faint cheese-like odour. The hue ranges from light brown to yellowish[6].

2.0 Literature Survey

P. D. Dharmaratne *et al.,* discussed that Waste polyethylene makes serious eco-friendly communal complications in Sri Lanka[8]. The volume of unproductive polyethene raises day-to-day, further aggravating environmental and social matters. Researching out the supreme appropriate explanation for this is a vivacious constraint. This study emphasises searching for ways to use this leftover polyethylene as a sustainable building material joining it with readily obtainable Coconut Fibre. To assess whether thermoplastic/coconut fibre composites are appropriate for use in the construction sector, a preliminary investigation was conducted in this study. The development of composite sheets with thicknesses of 2.5 mm and 3.2 mm changing using a hot press device and a suitable polymer matrix to weigh coir fibre. In this step, tensile and bending tests were used to gauge the mechanical characteristics of the composite material. The tests were performed per ASTM D790 and D3039, respectively. Scanning electron microscopy was used to examine the fractured surface of the failure material and the surface morphology of coir fibre (SEM). When the coir weight fraction is between 20 and 30 per cent of the total weight, the maximum tensile strength of 6.75 N/mm^2 is observed. When the coir fraction is close to 25% of the total weight, the maximum bending strength is 29.85 N/mm^2. The corresponding mechanical characteristics are contrasted with the industrially accessible materials.

R. Alavez-Ramirez *et al.,* explored the potential use of coconut fibre as a thermal isolating filler for sandwich-style ferrocement panel walls[9]. Thermal conductivity tests were performed to compare the thermal behaviour of coconut fibre-filled panel walls made of ferrocement to that of other local building materials that are more frequently used. The thermal conductivities of lightweight concrete brick panel walls, hollow concrete blocks, and red clay bricks are 0.93, 0.683, and 0.536 W/m K, respectively. The proposed arrangement's thermal conductivity, which is 0.221 W/m K, is lower than that of typical building materials used in nearby homes.

Abbas Mohajerani *et al.,* discovered that fibers have been utilized in construction materials for an extended period[10]. Natural and synthetic fibres have shown promising outcomes in prior research and investigations, regarding the overall physical and mechanical properties of the composite material; their presence has proven to have significant advantages. When compared to traditional reinforcement, the amount of fibre used is substantially lower, making fibre reinforcement both energy and cost-effective. Previously, the potential of using waste fibres as reinforcement in construction material has garnered praise. Leveraging waste yarns in building materials can benefit with these problems while also promoting ecologically beneficial and long-term solutions in the industry.

Mohammed L., *et al.,* discussed various natural fibers and emphasized the development of natural fiber composites, primarily focusing on applications that enhance their value[3]. The adaptable material system that has been created has the potential to be used as a wood substitute in applications like door shutters, flooring tiles, roofing sheets, and partitions, among others. It is anticipated that this material system will significantly contribute to the preservation of forests and environmental protection. The mechanical characteristics of natural fibres and the mechanical

properties of composite materials were enhanced by a chemical treatment procedure. Fibre shrinkage has a substantial impact during this process on the fabric structure as well as mechanical yarn characteristics such as tensile strength and modulus. Green-reinforced composites are also a comparatively innovative trend.

3.0 Outcome of Literature Survey

Synthetic fabrics like bagasse, coir, sisal, and jute are now receiving more heed from experts as a result of climate change as well as the depletion of petroleum resources. Polymer fibre-reinforced composites made from agricultural wastes are cost-competitive. Natural fibre-reinforced development has mainly focused on jute, coir, sisal, pineapple, ramie, bamboo, and other synthetic fibres. Green-reinforced composites are also a relatively new trend. Natural and synthetic fibres have shown promise in previous studies and examinations. Fibre reinforcement uses significantly less fibre than typical reinforcement, saving both energy and money. A potential material cost for roofing products like honeycomb structures and tiles is coir, a green building material. Unlike traditional reinforcement, fibre reinforcement uses significantly less tissue and would save both money and energy.

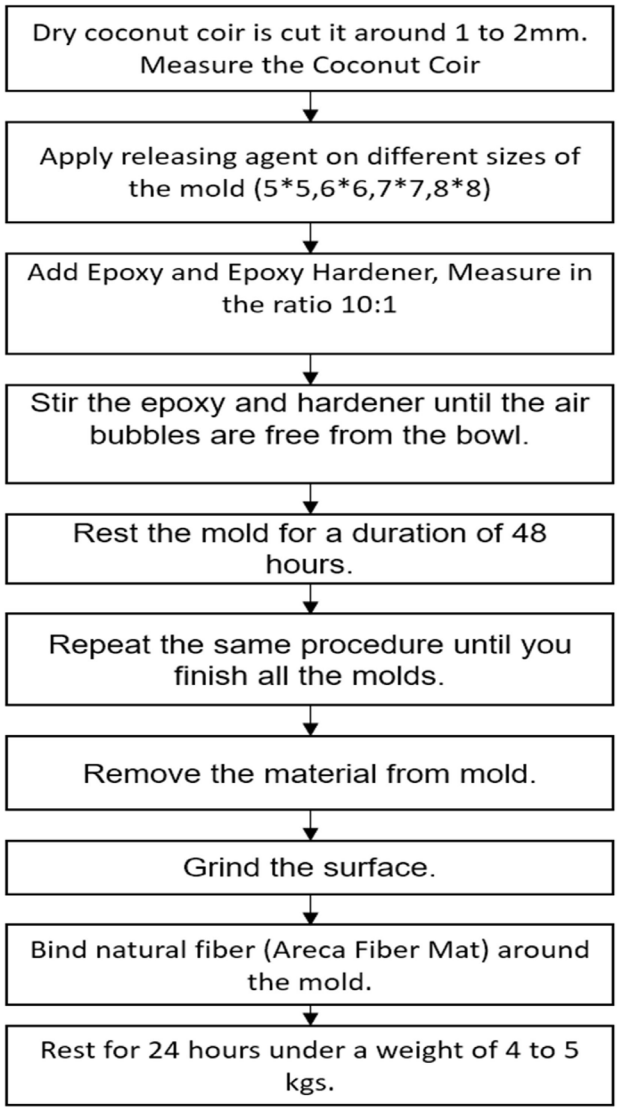
4.0 Problem Statement

The main purpose of the project is to determine the basic physical behaviour of the coconut fibre reinforced with epoxy resin in regard to physical properties, strength, and durability.

The specific aims of the project are:

Finding the ideal Epoxy and Hardener ratio will help you to create the best mix design for the number of fibres. To probe the bodily belongings of the fibre reinforced with epoxy resin – density (lightweight), strength (bending and compression), water absorption and moisture content. To increase the amount of information on the physical or behaviour of the composite material.

5.0 Methodology



6.0 Materials Used

Coconut Coir: It is a naturally present fabric made from the coconut's fibrous husk. It is biodegradable and adaptable to stress. Sacking, twine, doormats, and other commodities like bags, roofs, and ropes are made from coconut coir. Moreover, coconut coir may be employed in building and to continue making clays comfortable. The advantages of Coconut Coir are it is a renewable material, its composition is uniform throughout, prevents soil erosion, and promotes strong root growth.

Epoxy and Hardener: This is a continuous polymer phase that retains the reinforcing agent in place and plays a vital role in the degradable process. It is a polymer matrix that serves as a composite. The Epoxy Hardener's Function



Fig : Measuring of Coconut Coir



Fig : Cutting of Coconut Coir



Fig : Mixing Epoxy and Hardener



Fig : Measuring Hardener



Fig : Measuring Epoxy



Fig : Griding the Mold

Figure 1. Preparation photos.

Epoxy resins are fairly integrated substances that have a significant shelf life when it is used alone. They can't properly cure unless they are taken in conjunction with an epoxy hardener. The resin could not change into a dependable flooring system if it were applied to a floor without the adhesive because it would continue to stay nearly liquid forever.

Releasing Agent: A chemical used to prevent other materials from sticking to surfaces is also recognized as a mould-releasing agent.

Areca Fibre: It possesses a high potential for regrowth, is cheap, and is readily accessible. Areca Catechu Linnaeus is the areca's botanical name, and it is a member of the palm family Aceraceae. Areca fibres provide a 147 to 322 Mpa torsional stiffness span.

7.0 Experimentation

The different tests to find suitable results andwe can draw appropriate conclusions from the results. The different tests conducted on the sample are the Air Jet Erosion Test, Ball DropImpact Test, and Water Absorption.

The samples will undergo a series of Air Jet Erosion Test Procedure:

- Take note of the initial weight of thespecimen
- Set the workpiece at 90 degrees towards thenozzle
- Set the different parameters like speed, air pressure and time
- Remove the workpiece
- Note down the final weight of the specimen
- Using the Formulae, calculate the air jetwear loss by weight loss method

Formula: (Initial Weight/ Final Weight) *100



Figure 2. Mould after Air Jet Erosion Test.

7.1 Water Absorption Test Procedure

For the determination of moisture content, the specimens are dehydrated at room temperature for a set time and



(a)



(b)

Figure 3. a. Mould before Water absorption (Dry Weight) and b. Mould after Water absorption (Wet Weight).

weighed (Dry weight). Set the workpiece at 90 degrees towards the nozzle. The material is then immersed in water, often at room temperature and for a period of 1 hour or until equilibrium. Specimens are removed from the water and then weighed (Wet Weight).

Formula:

% Water Absorption = [(Wet weight -Dry weight)/ Dry weight] x 100

7.2 Ball Drop Rig Impact Test Procedure

Describe the direction of the impact plane, the drop height (h), and the gravity's acceleration (g). The body moves as a rigid body in the gravitational direction until it interferes with the rigid plane. Set the workpiece at 90 degrees towards the nozzle Specify the impact velocity (v), the acceleration of gravity (g), and the impact plane's position. In the test, a stiff sphere (typically steel) of known mass and diameter is dropped from a known height onto a sample of the material.

Calculate the required parameters i.e., W net, F net, Acceleration, Velocity and Force according to Newton's second law.

Formulae:

PE = KE

mgh = ½ mv^2 V = sqrt(2*g*h)

W net = ½ $mv(f)^2$ - ½ mv $(i)^2$F net = W net / d

a = (2* sqrt (2*g*h))/ t pulse (newton's) F = ma = (w/g) *a

8.0 Results

1 Air Jet Erosion Tester

Air Pressure: 43Psi /3kg/cm^2conveyor Speed: 3 rpm

Time (minutes)

	0- 5 mins	0-10 mins	0- 15 mins	0-20 mins	0-25 mins
Initial	9.91 g	10.078 g	10.10 g	10.082 g	10.051 g
Final	10.078 g	10.10 g	10.082 g	10.051 g	10.020 g
Weight	98.33	99.78	100.17	100.3	100.3

2 Water Absorption Test

Dry Weight (grams)	**93.05**
Wet Weight (grams)	110.20
% Water absorbed	18.43%

3. Ball Impact Rig Test

Comparison between clay tile, coir material, Blue Fibre Tail and Green Concrete Tail. These are the results of the Ball Impact test with different sphere weights are given below.

A. W1= 66.641gram = 66.641*10^{-3} kg

Height	Weight (kg)	Clay Tile (N)	Coconut Coir (N)	Blue Fibre Tile (N)	Green Concrete Tile (N)
0.8m	66.641*10^{-3}	72.55 *10^{-3}	64.33 *10^{-3}	65.3074 *10^{-3}	69.5249 *10^{-3}
1.1176m	66.641*10^{-3}	87.36*10^{-3}	77.71*10^{-3}	80.8797 *10^{-3}	85.0590 *10^{-3}
1.3716m	66.641*10^{-3}	99.65*10^{-3}	87.36 *10^{-3}	94.2786 *10^{-3}	97.7875*10^{-3}
1.6256m	66.641*10^{-3}	113.10*10^{-3}	103.45*10^{-3}	110.8613*10^{-3}	110.8008*10^{-3}
1.8796m	66.641*10^{-3}	125.80*10^{-3}	116.63*10^{-3}	130.5857*10^{-3}	124.4452*10^{-3}

B. W2= 286.73gram= 286.73*10^{-3} kg

Height	Weight (kg)	Clay Tile(N)	Coconut Coir(N)	Blue Fibre Tile (N)	Green Concrete Tile (N)
0.8m	286.73*10^{-3}	304.28*10^{-3}	276.79 *10^{-3}	285.2173*10^{-3}	287.4029*10^{-3}
1.1176m	286.73*10^{-3}	372.2479*10^{-3}	331.74*10^{-3}	345.0444*10^{-3}	347.8181*10^{-3}
1.3716m	286.73*10^{-3}	437.99*10^{-3}	401.59 *10^{-3}	391.4742*10^{-3}	398.3850*10^{-3}
1.6256m	286.73*10^{-3}	509.67*10^{-3}	453.33*10^{-3}	441.3827*10^{-3}	449.4843*10^{-3}
1.8796m	286.73*10^{-3}	576.38*10^{-3}	523.18*10^{-3}	502.2865*10^{-3}	523.6713*10^{-3}

C. W3 = 437gram = 437*10^{-3} kg

Height	Weight (kg)	Clay Tile(N)	Coconut Coir(N)	Blue Fibre Tile (N)	Green Concrete Tile (N)
0.8m	437*10^{-3}	471.30*10^{-3}	437.44 *10^{-3}	441.4324*10^{-3}	572.6519*10^{-3}
1.1176m	437*10^{-3}	578.21*10^{-3}	567.52*10^{-3}	557.7769*10^{-3}	534.4287*10^{-3}
1.3716m	437*10^{-3}	673.98*10^{-3}	640.57 *10^{-3}	623.5098*10^{-3}	617.918*10^{-3}
1.6256m	437*10^{-3}	749.71*10^{-3}	726.10*10^{-3}	698.0985*10^{-3}	726.6061*10^{-3}
1.8796m	437*10^{-3}	844.59*10^{-3}	901.61*10^{-3}	798.1180*10^{-3}	835.2586*10^{-3}

D. W4= 535 gram= 535*10^{-3} kg

Height	Weight (kg)	Clay Tile(N)	Coconut Coir(N)	Blue Fibre Tile (N)	Green Concrete Tile (N)
0.8m	535*10^{-3}	587.90*10^{-3}	557.35 *10^{-3}	524.2945*10^{-3}	572.6519*10^{-3}
1.1176m	535*10^{-3}	714.96*10^{-3}	670.24*10^{-3}	676.8459*10^{-3}	689.0417*10^{-3}
1.3716m	535*10^{-3}	808.22*10^{-3}	784.23 *10^{-3}	800.5947*10^{-3}	817.1033*10^{-3}
1.6256m	535*10^{-3}	928.20*10^{-3}	888.93*10^{-3}	908.6811*10^{-3}	929.1039*10^{-3}
1.8796m	535*10^{-3}	1047.09*10^{-3}	1010.01*10^{-3}	1010.6095*10^{-3}	1034.9629*10^{-3}

After conducting the Air Jet Erosion test, we observed that the weight of the mould increased with time. The weight of the mould increases due to the water being absorbed by the mould. The impact strength of various materials has been tabulated below using the Ball Impact Rig Test Machine.

9.0 Inferences

As discussed above, the project looked at approaches to reduce the volume of adverse effects for the conditions coir waste that was discarded in the vicinity on a routine basis. Therefore, we end up making coir with fibre reinforced

roof tiles out of surplus coconut coir to attempt to decrease as well as apply this sludge within that civil construction field. We made every attempt to make effective tiles that use these materials, but doing so is currently difficult due to the unprofitable production of these tiles. It is possible to use an eccentric chemical for binding material, such as epoxy or another, which may be feasible in the future.

The present study focuses on the bio-climatic design and thermo physical actions of roof installation produced and made up of externally bonded sandwich processes typically loaded with coconut fibre to be utilized as construction material.

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