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Particle board using rice husk and coconut fibre.
Tablero de partículas con cáscara de arroz y fibra de coco

Ajay Chandran[1,a], Althaf Ismail[1,b], Bestin Charles[1,c], Thejal Tom Thejal[1,d]

Civil Engineering, St Joseph's College of Engineering and Technology, Kottayam, India
email(a): todajay99@gmail.com; email(b): althafismail271@gmail.com; email(c): besthincharles@gmail.com; email(d): thejaltom@gmail.com

ABSTRACT

Particle boards are one of the primary products used in buildings and furniture sectors. These materials are manufactured under pressure, by combining wood particles and other lignocellulosic fibrous materials by using an adhesive. The extensive use of particle boards can add to the economic advantage of low-cost wood raw material, inexpensive agents and, simple processing. For the manufacturing of particle boards based on renewable resources, the search for lignocellulosic substitutes for wood is one of the biggest challenges that the wood industry is facing. In this project, particle boards were made using rice husk and coconut fibre, as a substitute for wood. Rice husk is the hard-protective shell of grains, obtained from rice mill. Coconut fibre is the natural fibre extracted from the coconut husk. Three boards of different coconut fibre content (15%, 20%, and 25%) were casted. The coconut fibre and rice husk were exposed to Alkali Treatment to make the fibre free from hydrophobic substances. They were then processed into particle board using poly-ester resin as binder. The effect of fibre content on Density, Water Absorption (WA), Thickness Swelling (TS), Modulus of Rupture (MOR) and Modulus of Elasticity (MOE) were analyzed. This investigation appears as a better solution for environmental problems associated with wastes and it is economical to use for the manufacturing of composite fibre boards.

Keywords—particle board, composite board, waste recycling, coconut fibre, rice husk, poly-ester, different proportions.

RESUMEN

Los tableros de partículas son uno de los principales productos utilizados en los sectores de la construcción y el mobiliario. Estos materiales se fabrican a presión, combinando partículas de madera y otros materiales fibrosos lignocelulósicos mediante el uso de un adhesivo. El uso extensivo de tableros de partículas puede aumentar la ventaja económica de la materia prima de madera de bajo costo, agentes económicos y un procesamiento simple. Para la fabricación de tableros de partículas basados en recursos renovables, la búsqueda de sustitutos lignocelulósicos de la madera es uno de los mayores desafíos a los que se enfrenta la industria de la madera. En este proyecto, se fabricaron tableros de partículas utilizando cáscara de arroz y fibra de coco, como sustituto de la madera. La cáscara de arroz es la cáscara protectora dura de los granos, que se obtiene del molino de arroz. La fibra de coco es la fibra natural extraída de la cáscara del coco. Se moldearon tres tablas de diferente contenido de fibra de coco (15%, 20% y 25%). La fibra de coco y la cáscara de arroz se expusieron a un tratamiento alcalino para liberar la fibra de sustancias hidrófobas. Luego se procesaron en tableros de partículas utilizando resina de poliéster como aglutinante. Se analizó el efecto del contenido de fibra sobre la densidad, la absorción de agua (WA), el hinchamiento del espesor (TS), el módulo de ruptura (MOR) y el módulo de elasticidad (MOE). Esta investigación aparece como una mejor solución para los problemas ambientales asociados con los desechos y su uso es económico para la fabricación de tableros de fibra compuesta.

Palabras clave: tableros de partículas, tableros compuestos, reciclaje de desechos, fibra de coco, cáscara de arroz, poliester, diferentes proporciones.

INTRODUCTION

Approximately 95% of the lignocellulosic material used for particleboard production is wood. The use of this renewable source for industrial applications in the production of light boards can help to reduce the impact on the environment. Coconut is a renewable resource and natural fibre extracted from the husk of coconut known as coir which offers properties such as resilience, strength, damping, resistance to weathering due to the presence of lignin and lower cellulose and hemicellulose. Rice husk is the by-product in milling operation which is easily available which possess pozzolanic nature due to the presence of high concentration of silica.The objective of present research is to develop green composite by using lignocellulosic coir fibres which are abundant, inexpensive and eco-friendly and improving the new era of green composites.

The purpose of this particle board is to reduce waste of coconut fibre, rice husk and transform into useful product.Natural fibre such as coir fibre is the most available fibre with light weight, biodegradable, inexpensive which are more generally competent to synthetic fibres. The green composites would serve as major drivers of sustainable developments to automakers, making significant shift towards eco-friendly composites to reduce manufacturing cost and fuel usage while meeting the consumer demand for greener products.

MATERIAL AND METHODS

Material Collection: Coir fibres which are collected from local ventures of Alappuzha and Rice husk are collected from rice mill in Kalady. Processing of Materials-In order to clean the raw materials, they were treated with Sodium Hydroxide (NaOH) solution. The treatment removes waxy substances on the fibre surface, thereby improving the close contact of the fibre matrix and leads to improve the surface roughness of the fibres. The fibres were soaked in 5% NaOH solution for 2 hours having fibre to liquid ratio of 1:50 and stirred occasionally.The rice husks are further washed with large amount of water and sun dried for 48 hours. After cleaning, the coconut fibre was cut into lengths of 10mm and rice husk was crushed and the particles passing through 300µm standard sieve were used.

Mixing and Compaction: The unsaturated polyester resin was weighed by gently pouring it into a plastic container placed on a digital weighing balance until the weight needed for that particular formulation was achieved. The catalyst, methyl ethyl ketone peroxide (MEKP), was weighed by placing a beaker on the digital weighing balance and in it a test tube placed and the catalyst added gradually into the test tube with the help of a syringe, the weight indication was observed as more drops of catalyst were continually added until the desired weight needed for a particular formulation was achieved. The same procedure was used for Cobalt Napthenate accelerator. The weight of catalyst and accelerator were determined by the weight of unsaturated polyester resin. In this project, different boards are fabricated by keeping the binder content constant and varying the fiber content. In general, the ratio of unsaturated polyester resin to catalyst to accelerator was 200gm: 2gm: 2gm respectively. During blending, the mass of coconut fibre and rice husk was varied with that of the unsaturated polyester resin to give a total of 400g. The particle boards having different fibre content were prepared by varying the coconut fibre weight fraction from 15% to 25%. The cleaned fibres, were weighed according to the percentages needed (Coconut fibre: 15%.20% and 25%, Rice Husk: 35%, 30% and 25%). After weighing, the coconut fibre and rice husk were mixed together. Following that, the unsaturated polyester resin was taken with 1:1 weight percentage to the fibre used. 1%weight of catalyst was added to the unsaturated polyester resin. The mixture was then stirred until it became homogenic mixture. After that 1% weight of accelerator were added and mixed well. Then the fibre mixture is added to the resin and mixed uniformly using a spatula. Then the mixture was transferred carefully into the mould and flattened appropriately by using the roller. The covering plate were placed over the mixture and kept under the compression testing machine. Particle boards are prepared with 3 different fibre contents. The detailed composition and mix proportion of the particle board are presented in table. The cast of each particle board was preserved under a load of about 100kN for 1 hour. Then this cast is kept for curing.

Table I. Mix Proportion

Material	Board-1	Board-2	Board-3
Rice Husk	35%	30%	25%
Coconut Fibre	15%	20%	25%
Resin	50%	50%	50%

Curing-After loading, the particle board was oven dried at temperature of 65° C for 2 hours. Then this cast was post cured in room temperature for another 24 hours, after which the board is then removed from the mould. Specimens of appropriate dimensions were cut for physical and mechanical tests.


Fig. 1 Particle board before and after compaction

Testing and analysis: Water Absorption Test-The test was conducted as per ASTM standard D570-98. Five samples having size 40x40x10mm were taken from each board and weighed. Then it is soaked in water for 24 hours. There after they were removed from water, cleaned and reweighed. The weight gain in percentageof the samples were calculated by using the following equation.

$$\text{Water Absorption \%} = ((W_2-W_1)/W_1) \times 100$$

where, W_1- Dry weight of the specimen

W_2- Weight of specimen after immersion

Thickness Swelling Test: The test was performed in accordance with ASTM standard D570-98. Five samples having dimension 40x40x10mm were taken from each board and their thickness is noted. Then it is soaked in water for 24 hours. Thereafter they were removed from water, cleaned and thickness after immersion in water is taken. The percentage thickness swelling was calculated from the equation,

$$\text{Thickness Swelling} = ((T_2-T_1)/T_1)/ \times 100$$

where, T_1- Thickness of sample before immersion in water

T_2- Thickness of sample after immersion in water

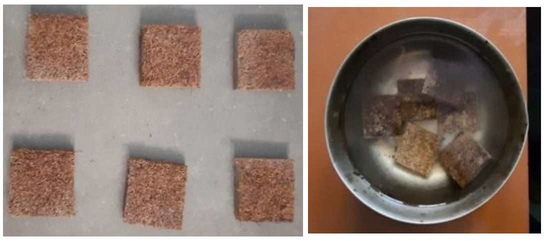

Fig. 2 Test samples for water absorption and thickness swelling tests

Flexural Strength Test: The main objective of the test is to determine the mechanical properties such as modulus of elasticity (MOE) and modulus of rupture (MOR) of the particle board. The flexural strength was carried out at room temperature through 3-point bending test on universal testing machine (UTM). The specimens were prepared according to ASTM D790-02 with dimension 250mm X 25mm X 10mm. The specimen was freely supported at the two ends and a point load was applied in the middle of the specimen. Five sample of each board type were tested and average value is tabulated. The test consisted of applying a constant strain on fibres and measures the load. The deformation developed by applying the load was determined using a dial gauge. The bending strength of the specimen was given as the ratio of bending moment (at maximum load) to the moment of its cross section. The modulus of elasticity (MOE) was calculated from the linear region of load vs deformation curve.

$$\text{Modulus of Elasticity, } E = \frac{PL^3}{48I\delta}$$

Where, P- Breaking Load

L-Unsupported length of the specimen

I-Moment of inertia

δ-Deformation

$$\text{Modulus of Rupture, } \sigma = \frac{6Mu}{Bd^2}$$

Where, Mu-Bending moment

Mu= (P/4) * L

b- Width of specimen

d- Depth of specimen

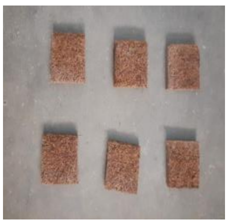

Fig. 3 Test sample for flexural strength test

RESULT AND DISCUSSIONS

Boards having different fibre content were tested to analyse and compare physical properties such as Water absorption and Thickness swelling, and mechanical properties like Modulus of Elasticity and Modulus of Rupture.

Water Absorption and Thickness Swelling-Five samples from each board type were tested for water absorption and thickness swelling. The average values of water absorption and thickness swelling for each particle board type are listed in table II and III respectively. Figure 4 shows the variation of physical properties with coconut fibre weight fraction.

Table II. Percentage water absorption of different boards

Board Type	Water Absorption (%)
Board 1	7.43
Board 2	8.29
Board 3	10.66

Table III Percentage thickness swelling of different boards

Board Type	Thickness Swelling (%)
Board 1	1
Board 2	2.6
Board 3	4.62

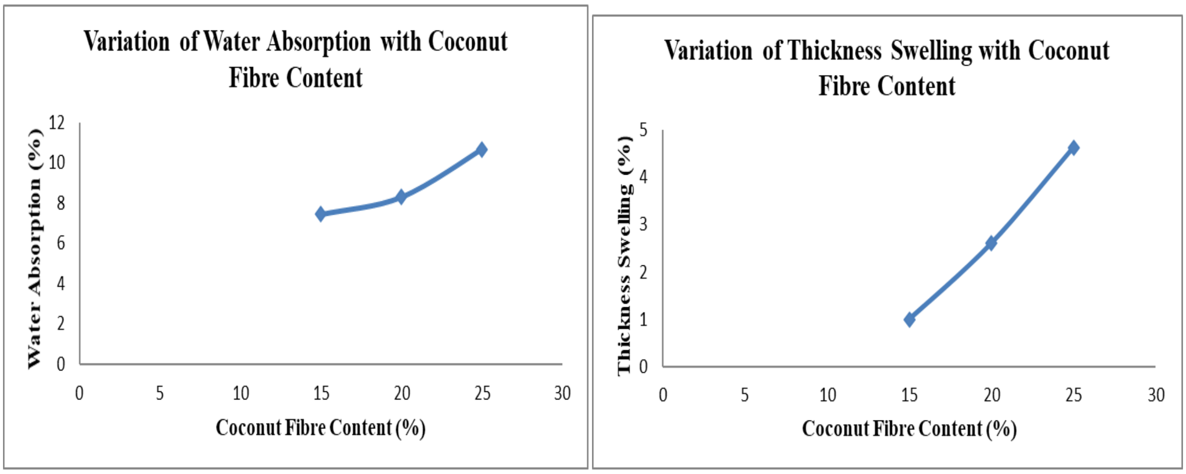

Fig. 4 Variation of Physical properties with coconut fibre content

As the coconut fibre weight fraction increases, the fibre-matrix adhesion decreases and thus the void space in the board increases, resulting in the increase in water absorption and thickness swelling.

Flexural Strength-Flexural strength is the ability of the material to withstand bending forces applied perpendicular to its longitudinal axis. The samples of each board type were subjected 3-point bending test on universal testing machine.

Table IV Modulus of Elasticity and Modulus of Rupture of different boards

Board Type	Modulus of Elasticity (N/Mm^2)	Modulus of Rupture (N/Mm^2)
Board 1	1600	8.4
Board 2	1333.6	7.2
Board 3	1000	6.6

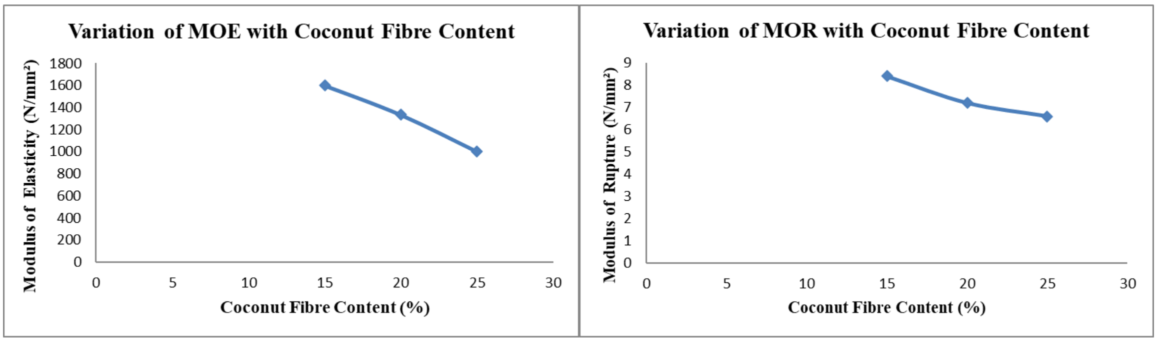

Fig. 5 Variation of Mechanical properties with coconut fibre content

From the above results, it is clear that, the values of modulus of elasticity (MOE) and modulus of rupture (MOR) decreases as the coconut fibre weight fraction of the board increases. The increase in coconut fibre content from 15 to 25 weight percentage results in fibre agglomeration and decreases the fibre-matrix adhesion, resulting in lower flexural strength values.

As conclusion, this study investigated the physical and mechanical properties of particle board made from coconut fibre, rice husk and unsaturated polyester resin to investigate the potential for the use of coconut fibre and rice husk as raw materials for non-wood bio-based particle board. Boards having 3 different coconut fibre weight fraction (15%, 20% and 25%) and corresponding rice husk content (35%, 30% and 25%) were casted and tested for physical (Water absorption, Thickness swelling) and mechanical (Modulus of elasticity and modulus of rupture) properties. From the results obtained, the water absorption and thickness swelling of the board are found to be increasing with increase in the coconut fibre weight fraction which is due to the decrease in adhesion between the fiber and resin. The minimum values of water absorption and thickness swelling were obtained as 7.43% and 1% respectively. As the coconut fibre weight fraction increased from 15% to 25%, the values modulus of elasticity and modulus of rupture were decreased which is due to the fibre agglomeration that leads to the decrease in fibre-matrix adhesion. Rice husk, which is used as the filler material, increases linearly with decrease in coconut fiber content and thus the filler-resin bonding increases and hence improves the mechanical properties. The maximum values of modulus of elasticity and modulus of rupture were obtained as 1600N/mm^2 and 8.4N/mm^2 respectively. From the studies carried out, the optimum values of physical and mechanical properties were obtained from the first type of board having the mix proportion as, rice husk 35%, coconut fibre 15% and unsaturated polyester resin 50%.

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