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Hybrid Coir Medium Density Fibreboard Made of Coir and Basalt fiber using Urea-formaldehyde resin

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Abstract

In today's world, the furniture sector has been developed greatly due to engineering products' production. This makes all researchers do research on engineering products in recent times for the past 20 years, and also the waste outlet of agro-industry was increased. The reason beyond the engineering products was a limitation on natural woods, more agro waste, natural disaster in the forest, and many more. The coconut is a very important crop in India, and it produces large quantities of coir fiber. The usage of fiber was the vast production of byproducts. Similarly, the engineering of wood also increased year by year in production for commercial purposes. In this project, the medium density fibreboard was prepared from coir fiber and basalt fiber and made into the panel. The Urea-formaldehyde (UF) bonding agent was prepared, and the pH value was maintained while preparing the resin. The panel was prepared with different combinations from panels 1 to 8 using a thermoset molding machine, but the resin (UF) was constant. The fibreboard characteristic was found through the SEM image. Finally, the physical and mechanical properties like density, moisture content, modulus of Rupture, modulus of elasticity, and internal bonding strength were found for 8 different MDF panels. The main purpose was to utilize agro-waste materials into useful products.

Keywords: *coir fiber, basalt fiber, Modulus of Rupture, Modulus of Elasticity*

I. Introduction

The growth of the furniture sector increases year by year, due to the development of technology. The furniture market is basically classified into three categories, with the percentage of domestic (65%), office/corporate (20%), and contract (15%). In this entire category, wood plays an important role in the production of furniture. Throughout the world, the usage of wood was increased very high in recent times. Recently World Bank reported that 1.3 million square km was destroyed between 1990 and 2016. Similarly, in India between 2000 and 2018, 16,744 square km was lost due to deforestation. Due to vast deforestation, the natural wood used was reduced in recent times. The main reason was the utilization of engineering products like plywood, medium-density fibre board, particleboard, laminates, etc. In this, plywood is used more when compared to medium-density fibreboard in the Indian market, but it is vice versa in the world market. Generally, engineering woods were produced from softwood and hardwood and are the most used material for the construction of furniture. The fibreboard was prepared from different agro materials like wheat straw, rice straw, sugarcane, cotton stacks, bamboo, groundnut shells, rubberwood, oil palm, kenaf, etc. ([1], [2], [3], [4], [5], [6], [7]). The preparation and properties are also explained in detail ([8], [9]). Similarly, the hybrid board was also prepared by using agro materials ([10], [11], [12]). In recent times, the MDF market was increasing year by year, especially in the furniture, packing, and construction sector. At the same time, the import was also increasing gradually from other countries.

Generally, MDF means medium density fibreboard, the fiber blended with resin and compressed with temperature and pressure. Through coconut trees, numerous byproducts can be produced, in which oil, milk, honey, rope, mate, wood, etc. then the coconut coir also can be used to produce more products ([13], [14]). With that, the Engineering wood also is produced from coconut coir. When the coir was extracted from coconut husk through a fiber extraction machine, in which coir pith and coir fiber were separated. Then, the fiber was separated into the short and long fibre. The short fibre was used for making a tufted mat, and the waste outlet was used to prepare MDF in this work. India is one of the most important countries in the export of coir products [15], which produces a large quantity of coir waste from coir plant. Similarly, the basalt fiber was mixed with coir fibre. A number of resin was available in the market, namely urea-formaldehyde, phenol-formaldehyde, melamine, bio-resins, etc. The urea-formaldehyde has some advantage over other resins like more hardness, excellent thermal property, resistance to microorganisms, etc. already, this resin has been used more in engineering wood production. So, the coir and basalt fibre was used to produce engineering wood.

II. Materials and Methods

A. Materials

The raw material for the panel was coir fiber, which was collected from the coir plant. Second, the urea-formaldehyde resin was prepared in our institute. The procedure carried out was 40% formaldehyde solution was used, in which 200 ml was taken in the 1000 ml beaker. Then by adding about 100 grams of urea to the formaldehyde solution and stir. Add a few drops of concentrated Sulphuric acid with stirring continuously during adhesion. When the reaction is complete, pass the residue with water. One mole of the urea-formaldehyde resin was dissolved in 6 moles of epichlorohydrin, and the mixture was heated in a boiling water bath. The reaction mixture was stirred continuously for 16 hours. At the same time, 3 moles of sodium hydroxide in the form of 30 % aqueous solution was added dropwise. The residue obtained is washed several times with distilled water [16]. Similarly, the process was carried out to get a mass quantity. The mass quantity residue was fine powdered.

B. Preparation of panel

The panel was prepared by using a compression molding machine with the specification of Capacity of the press is 25 ton, mold size is 300 x 300 x 5 mm^3, Pressing speed is 25 mm/sec Working pressure=25 kg/cm^2 and Heating range=145°C. The proportion mentioned in the table is in weight percentage, and the materials were mixed through the hand. Then, the urea-formaldehyde resin powder was blended with the fiber and hexamine; the curing agent was also added to the mixture with the proportion of 10:1 and placed in the mold. The machine was switched on and set the temperature of 145°C, and the mold was placed in the machine. Then the material was compressed with heat for 8 min and without heat for 60 min. Here, only the proportion of coir fiber and sawdust was changed in every panel and made 9 panels from p1 to p9. Later, the panel was separated from the mold and cut into standard size to test the mechanical and physical properties. Figure 1 explains the whole process of preparation of the MDF board using coir and basalt fiber, and figure 2, the sample of fiberboard.

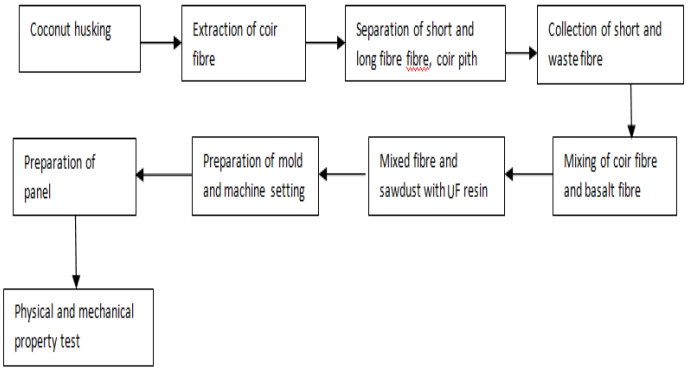

Figure 1: Methodology for MDF panel preparation

Figure 2:Samples of fiberboard

C. pH value Determination

The urea-formaldehyde powder was taken and weighed 5 gm through a weight machine. Then the sample was added to the flask, and 100 ml of distilled water was mixed into the sample. After shaking the mixture for a minute, the pH meter was used to measure the pH value at normal temperature.

D. Characterization of hybrid MDF using SEM

The SEM image was taken with the model of TESCAN VEGA3, and this is a thermionic emission system that comes with tungsten heated filament as the electron source. VEGA3 is used for both low and high vacuum operations, and also it is a versatile system.

E. Physical and Mechanical Properties Test Method

The physical properties, like density, were carried out with the basic calculation mentioned below.

$\rho = \frac{m}{l*b*t} * 106\ kg/m^3$, where m is mass of test specimen (g), l, b, and t is the length, breadth, and thickness of the specimen (mm). Similarly, the moisture content was tested with the dimension of ASTM D1037. The mechanical properties like MOR, MOE, and IB strength were also found for the prepared MDF material with the standard size of ASTM D1037.

III. RESULT AND DISCUSSION

A. Characterization of hybrid MDF using SEM

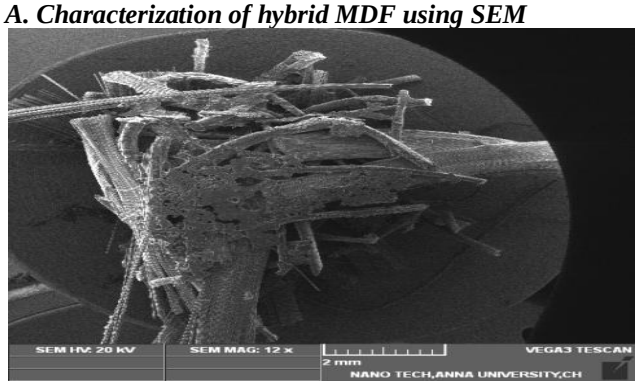

Figure 3a: Agglomerated fiber in the panel

Figure 3a explained the agglomeration of fiber and bonded with a urea-formaldehyde resin. The coir fiber and basalt fiber were placed together with the bonding agent, and voids were found on the panel. The image was taken in panel no 1 with coir 40% and basalt 40% composition and 2mm distance.

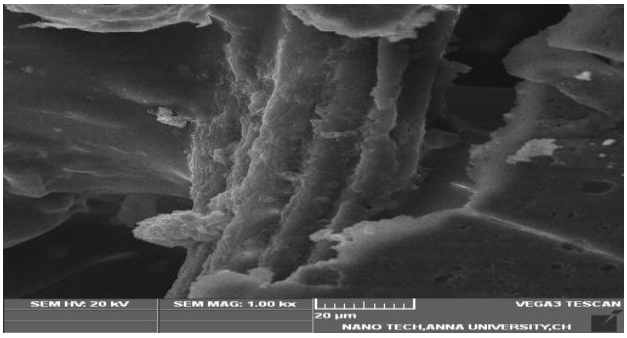

Figure 3b: SEM image of hybrid coir MDF -UF resin on the surface of the fiber

Similarly, figure 2b image was taken with 2µm distance for the same panel. In this, the urea-formaldehyde was scattered on the surface of the fiber, and the bond between the fiber was good. So, the coir and basalt fiber was tightly packed in the panel with the urea-formaldehyde resin.

B. Physical and Mechanical properties of MDF

TABLE 1: Proportion of fiber and Physical properties of different panel

Panel no	Coir %	Basalt %	Resin %	density	Moisture content
1	40	40	20	763	13
2	45	35	20	745	11
3	50	30	20	751	12
4	55	25	20	786	10
5	60	20	20	748	11
6	65	15	20	753	14
7	70	10	20	771	14
8	75	5	20	734	11

Here 8 different panels were prepared with different coir and basalt fiber proportions, and the resin content was fixed as constant. The panel was named p1 to p8, which is mentioned in table 1. The physical and mechanical properties were carried out for each panel. First, physical properties like density and moisture content were found, and the values are recorded in table 1.

In which the values are range from 734 to 786, and the panel P4 has the maximum value with the coir of 55% and basalt of 25%. Similarly, the moisture content was ranged from 10 to 14, in which the P4 has less value compared to all other panels.

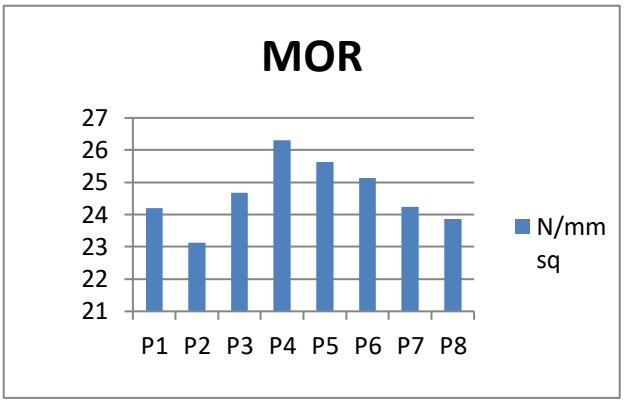

Figure 4: Modulus of Rupture for 8 different MDF panel

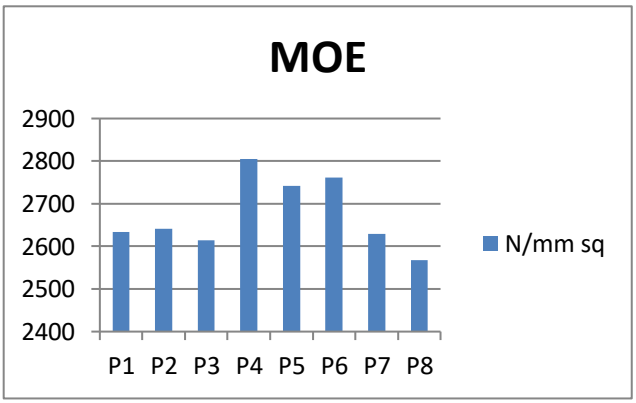

Figure 5: Modulus of elasticity for 8 different MDF panel

Second, the mechanical properties like modulus of Rupture (MOR), modulus of elasticity (MOE), and internal bonding strength (IB) were carried out. When considering MOR, the value ranges from 23.13 N/mm^2 to 26.3 N/mm^2, in which panel no P4 has the maximum value of 26.30 N/mm^2. This is due to the higher density, maximum of modulus of Rupture. The value of MOR is increasing gradually from panel 1 to 4 and reaches the maximum value, then from panel 5 to 8, it decreases. Similarly, the modulus of elasticity also has the maximum value of 2805 N/mm^2 for panel no 4. The value of MOE is ranging from 2567 N/mm^2 to 2805 N/mm^2. Generally, the bending strength increases with an increase in density [17].

When considering internal bonding strength, the bonding between the fibers in the panel is varying one to another. Figure 5 shows the variation of strength similar to bending strength. When considering panel p1 to p8, the IB value has a maximum in panel p4 with coir 55% and basalt 25%. The panel p7 has a low value of 1.49 N/mm^{2,} respectively. Overall the density is directly proportional to mechanical properties.

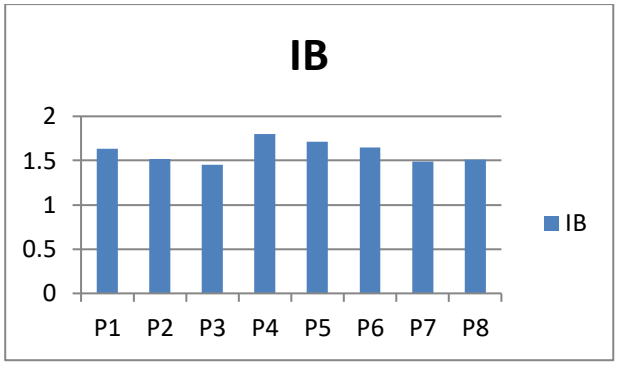

Figure 6: Internal Bonding strength for 8 different MDF panel

IV. CONCLUSION

Here I like to conclude that the preparation of urea-formaldehyde was done, and the pH value was found with the neutral value. Then, the microscopic image was taken through SEM, and the bonding between the fibre and fibre was observed. The fibreboard was prepared with the addition of UF resin and the hardener. Finally, physical and mechanical properties were found for 8 different panels, in which the panel has coir 55% and basalt 25% has maximum mechanical properties. This is due to when the density increases, the mechanical properties increases, and the moisture content decreases. This board was prepared with the waste outlet of coir plant and basalt fibre and is also one type of hybrid board used for commercial application.

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