ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 203-209, June 2021

SUITABILITY OF MEDIUM DENSITY FIBER BOARD MADE FROM RUBBER WOOD FOR HOUSEHOLD AND INDUSTRIAL USE

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Abstract

The use of fiber board is increasing due to limited supply of timer wood. This study investigated the suitability of medium density fiber board (MDF) made from rubber wood for household and industrial use. Rubber wood was collected from Bangladesh Forest Development Corporation (BFIDC), Chattogram. Single layer fiber boards were fabricated by five different densities, such as 700, 725, 750, 775 and 800 kgm^{-3}. The mechanical and physical properties of medium density fireboards fabricated by rubber wood fiber as a raw material and urea formaldehyde as a resin were studied. The performance of composite was evaluated by its mechanical and physical properties. Experimental investigation indicated that the mechanical strength of medium density fiber board such as modulus of rupture (MOR) and tensile strength increased with increasing board density. The bending strength (188-234kgcm^{-2}) passed the Indian, German and British standard while the tensile strength (4.20-4.70kgcm^{-2}) passed the German and British Standard specification. The research concluded that 800kgm^{-3} fiber board made from rubber wood had the best modulus of rupture (234 kgcm^{-2}) and the highest tensile strength (4.70 kgcm^{-2}) among all other single layer medium density fiber boards.

Keywords: Medium density fiber board (MDF), rubber wood, modulus of rupture (MOR), thickness swelling.

Introduction

The Food and Agricultural Organization (FAO) of the United Nations estimates that the production of industrial wood from plantations will be an increasingly important source of industrial fiber throughout the world (Evans,1998). Wood composite panels are a type of construction material used extensively as a raw material in furniture, shelving, cabinetmaking and other non-load-bearing construction applications. Two types of composite panels, such as particle board and fiber board are typically made using different techniques and materials. Fiber board is a type of engineered wood product that is made from wood fibers. There are three types of fiber board such as low-density fiber board (LDF), medium-density fiber board (MDF), and high-density fiber board (HDF).In general fiber board is considered as higher quality than particle board.

Medium density fiber board (MDF) is one of the most widely used wood-based panels to manufacture building and housing components such as furniture units for interior applications. In recent years, production of MDF has significantly

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increased and has a major market share in the wood composites industry **(**Julson*etal.,*2007, Akgul *et al.,*2008).

The demand for composite wood products, such as plywood, oriented strand board (OSB), hardboard, particle board, medium-density fiber board, and veneer board products has been recently increased substantially throughout the world (Youngquist,1999; Sellers, 2000).

The first MDF was made in a particle board plant in Deposit, New York in 1965.MDF capacity has grown rapidly. From the first production in 1965, world capacity is now estimated at $36x10^6 m^3 yr^{-1}$while in New Zealand capacity is some 900,000 $m^3 yr^{-1}$(Chapman,2004). Production of this product has increased dramatically and new plants are planned worldwide. In 1996, MDF shipments from U.S. plants set another annual record in an unbroken series, totaling 2.1 million m^3, which was forecasted to be 3 million m^3 in 1997.In 1996, European production of MDF jumped 18 percent to 4.5 million m^3, continuing an unbroken upward trend in Europe **(**Krzysik *et al,* 2001).

Rubber **(***Hevea brasiliensis***)** plantations are being raised in Bangladesh since the early sixteen for the production of latex. The wood of old trees whose latex production has declined can be used as rubber wood on a continuous basis (Hasnin *et al*, 1992). The present study was undertaken for finding out the suitability of fiber board from rubber wood. The shortage of the raw material for the forest industry is the main problem. To overcome the shortage of raw material this study aimed to examine the feasibility of using unusable rubber wood.

Materials and Methods

Fiber preparation

Rubber woods were collected from Bangladesh Forest Industries Development Corporation (BFIDC), Chattogram. Then woods were cut into pieces of shorter length in Veneer and Composite Wood Products Division, Bangladesh Forest Research Institute, Chattogram. The pieces were hammer milled to chips using screen of 0.63cm diameter. The chips were then sieved through 20-mesh screen to remove dust and fines and dried in the batch oven at 70ºC temperatures to 4 to 5% moisture content. The chips were cooked by direct steaming 120ºCin a stainless-steel rotary digester of 0.02 m^3 capacity under 10 $kgcm^{-2}$ digester pressures for one hour. They were then refined in a single-rotating disk attrition mill to obtain fiber of different freeness from each of the above cooks.

Fiber board manufacture

Five single layer fiber boards (MDF)were prepared under five treatments (T_1=700, T_2=725, T_3=750, T_4=775 and T_5=800 kgm^{-3}) in the laboratory hot press using the rubber wood fiber which followed by Latin Square Design (LSD). The dimension of the fiber board was 50 cm x 50 cm x 1.20 cm having a target density. The temperature of the platens of the hot press was maintained at 160°C. Liquid urea formaldehyde (UF) adhesive (50% solid content) was used on oven dry fiber for fiber board preparation. The liquid urea formaldehyde was catalyzed with 2% hardener (ammonium chloride) for hot pressing. No water repellent was used in this preparation. The mats of the board were formed manually in wooden fabricated bordered frame. Then the mats were pressed initially at 500psi specific pressure for 6 minutes. The pressure was then lowered in two steps, firstly 150psifor 4 minutes and then 50psifor 2 minutes according to the experimental condition shown in Table 1. The boards were then conditioned at 65 ±2% relative humidity and 20±2°C temperature before they were put to tests.

Table 1. Experimental condition

UF - solid content (%)	Board thickness (mm)	Board density (kg/m^3)	Pressing temperature (°C)	Mat moisture (%)	Specific Pressure (psi)	Pressure time(minute)
50	12	700-800	160	12	500	6
					150	4
					50	2

Test samples preparation

The fiber boards were cut into various test samples sizes such as (35.00cmx7.50cm x1.20cm) for modulus of rupture and (5.08cm x5.08cm x1.20cm) for tensile strength. The tests were carried out according to specification of IS: 2380 (Anon, 1977) with a constant loading speed of the testing machine at $12mmmin^{-1}$.

The parameters of modulus of rupture are as follows:

The modulus of rupture (equn.1), R can be found by substituting the maximum load, P for the load at the proportional limit

$$R = \frac{3Pl}{2bh^2} \quad (1)$$

Where, R=modulus of rupture in $kgcm^{-2}$

P=maximum load in kg

l=length of span in cm

b=width of specimen in cm

h=depth of specimen in cm

The tensile strength perpendicular to the surface was also carried out according to the specification of IS: 2380 (Anon,1977) with the exception that wooden blocks of 7.62cm x 5.08cm x 2.54cm were glued in cold press with the test specimens.

To determine thickness swelling and water absorption the specimens of size 10.16 cmx 10.16 x1.20 cm were taken from each board.

$$\text{(\%) Water absorption } = \frac{increaseofweightwithwater}{Ovendryweight} \times 100$$

The thickness of the specimens was measured with the platform type thickness gauze with an accuracy of 0.01 mm and immersed in 25 mm depth of coolwater.

$$\text{(\%) Swelling } = \frac{increaseindimensionorvolume}{originaldimensionorvolume} \times 100$$

At the end of 2 hours and 24 hours, the test specimens were withdrawn from water, wiped with a damp cloth, reweighed and re-measured the thickness as before. The percentage of water absorption and thickness swelling were then calculated. The test results were then compared with standard results given inTable2 and Table 3.

Statistical analysis

Analysis of variance (ANOVA) for the randomized complete block design was performed with the SPSS software package using the Least Significant Difference (LSD) method to compare the mean values of MOR,IB, TS and WA of the boards under various refining density at the 95% confidence level.

Table 2. Some standards specifications for strength property

Requirements/specification of some standards	Thickness of board (mm)	Density of board (kgm^{-3})	Modulus of rupture (MOR) ($kgcm^{-2}$)	Tensile Strength ($kgcm^{-2}$)
IS Specification 3087(Anon,1985b)	6-40	500 - 900	112.00	8.00
German Standard Din 68761 (Verkor, 1975)	13-20	600 -750	180.00	3.50
BS Specification 5669 (Anon, 1979b)	6-19	-	140.00	3.40

Table 3. Some standards specifications for dimensional stability (Thickness SwellingandWater Absorption)

Requirements/specification of some standards	Thickness of board (mm)	Density of board (kgm^{-3})	Thickness Swelling ((%))		Water Absorption ((%))	
			2hrs	24hrs	2hrs	24hrs
IS Specification 3087(Anon.,1985b)	6-40	500 - 900	10	25	-	50
German Standard Din 68761 (Verkor, 1975)	13-20	600 -750	6	-		-
BS Specification 5669 (Anon.,1979b)	6-19	-	12 (for 1hr soaking)	-		-

Results and Discussion

The results of analysis of variance (ANOVA) show that the effects of five different densities (T1=700, T2=725, T3=750, T4=775 and T5=800 kgm-3) have significant effects ($p \leq 0.01$) towards the modulus of rupter (MOR), thickness swelling (TS) and water absorption (WA). Tensile strength is higher significant than all other parameters and the significant ($p \geq 0.05$) value was 0.441259. The mean values according to least significant difference (LSD) of MOR,IB,TS and WA are given in Table4.

Measurements of modulus of rupture in static bending (MOR) and the tensile strength (internal bondIB perpendicular to face properties are presented in Table 4. The data in Table 4 revealed that the bending and tensile strength values have increased with increasing fiber board density, which are not proportional across the treatments.

Fiber boards containing density 800kgm^{-3}hadsignificantly ($p \geq 0.01$) the highest values of modulus of rupture among all other medium densities (Table 4). The value is234.00kg/cm^2 (Table4),which superseded the Indian- (112.00$kgcm^{-2}$), British- (140.00$kgcm^{-2}$) and German- (180.00$kgcm^{-2}$) Standard(Table 2).

All density boards tensile strength values were insignificant at 0.01% level (Table4). Fiber board made from different densities meet the requirement of German Standard Din:68761 (Verkor and Ledune,1975) and British Standard, BS:5669(Anon.,1979b) but did not fulfill the requirement Indian Standard Specification IS:3087 (Anon.,1985b). The higher density MDF makes it stronger and more resistant to breaking when under heavy loads. Franz *et al.* (1975) pointed out that modulus of rupture is the most important mechanical property of particle board with respects their particle application as structural elements.

Table 4. Strength property and dimensional stability of MDF made from rubber (*Heveabrasiliensis*)Wood

	Board density (kgm^{-3})	Modulus of rupture (MOR) ($kgcm^{-2}$)	Tensile Strength ($kgcm^{-2}$)	Thickness Swelling (%)		WaterAbsorption (%)	
				2hrs	24hrs	2hrs	24hrs
	700	188	4.20	6.22	11.08	34.63	45.45
	725	190	4.40	7.30	11.73	39.81	48.68
	750	197	4.50	7.50	11.92	43.44	52.62
	775	200	4.60	9.09	12.76	53.34	53.95
	800	234	4.70	9.10	12.87	54.42	63.22
F-value		28.23	1.02	69.52	8.43	1882.52	1892.76
Significant value		1.99E-05	0.441259	2.94E-07	0.003029	2.46E-14	2.39E-14

The observed thickness swellings of the different types of boards were 6.22 - 9.10% after 2 hours and 11.08-12.87% after 24 hours water soaking (Table 4). The average values of thickness swelling and water absorption for 24 hours immersion are greater than 2 hours immersion. Thickness swelling and water absorption values were significant at 0.01% level. It was found that, 2 hours thickness swelling of 800 kgm^{-3} density board satisfied the values of Indian Standard IS: 3087 (Anon., 1985b) and German Standard (Verkor and Ledune, 1975) specification. However, less water absorption is better than more absorption and less thickness swelling is better than more swelling. The table (4) revealed that the physical properties (thickness swelling and water absorption) increased with the increase of the board density. Density 800$kgm^{-3}$was very significant at 0.01% level and had better performances among all other parameters.

MDF boards are commonly used as interior for household purposes. Since household furniture is kept at a safe distance from water, it is less prone to water absorption and thickness swelling. Kollman *et al. (*1975) reported that the highest thickness swelling after two hours immersion in water should not exceed 6-10% of the original thickness. Addition of additives may improve the properties of the particle boards.

Conclusion

According to the test results it can be concluded that higher mechanical properties were obtained for denser panels of medium density fiber board made from rubber wood fiber. The results revealed that the 800 kgm^{-3} density rubber wood fiber board had the highest values for all the parameters and comparable to other rubber wood fiber boards. Other medium density fiber boards (700 kgm^{-3}, 725 kgm^{-3}, 750 kgm^{-3} and 775 kgm^{-3}) made from rubber wood can also be used conventionally.

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