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Full Length Research Paper

Physical and mechanical properties of Agriculture plastic composite made from jute (*corchorus olitorius* l.) and dhaincha (*sesbania cannabina* retz.)

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A study was undertaken to identify jute (*Corchorus olitorius* L.) and dhaincha (*Sesbania cannabina* Retz.) sticks for Agricultural Plastic Composites (APC). In this study, JCF (Jute Coarse and Fine), DCF (Dhaincha Coarse and Fine), JF (Jute Fine) and DF (Dhaincha Fine) boards were produced. The density of JCF, DCF, JF and DF was respectively 0.93, 0.95, 0.86 and 0.92 g/cm^3. JCF, DCF, JF and DF showed MOR in dry condition 18.75, 24.01, 12.14 and 15.04 N/mm^2, respectively. The MOE of JCF, DCF, JF and DF for dry condition was 2301.05, 2960.85, 1038.17 and 1307.59 N/mm^2, respectively. All the boards made of coarse and fine from jute and dhaincha showed satisfactory results of physical and mechanical properties. Hence, it can be concluded that Agricultural Plastic Composites (APC) from jute and dhaincha sticks can be an alternative raw materials for manufacturing plastic composites in near future.

Key words: *Corchorus olitorius*, *Sesbania cannabina*, physical properties, mechanical properties, MOR (Modulus of Rupture), MOE (Modulus of Elasticity).

INTRODUCTION

Particles or fiber of lingo-cellulosic material bonded together with each other and produce in panel form are gradually gaining importance in a number of countries in the world. Worldwide economic growth and development have generated unprecedented needs for converted forest products such as pulp and paper, composite boards, plywood and lumber (Youngquist et al., 1993). This global demand started with the advent of the industrial revolution resulting in aggressive deforestation (Adger and Brown, 1994). Plastic products began appearing in the U.S. markets in the late 1980s. Its development was stimulated both by the rising volume of largely un-recycled plastic waste for which uses were needed as well as by increasing consumer interest in more durable, lower maintenance outdoor products such as decking and fencing. The major selling points for composite lumber are that it is free of potentially hazardous chemicals and made largely from long-lasting, low-maintenance, recycled materials. Thus, it is, often promoted as an environmentally preferable or “green” alternative to other decking materials (Bowyer et al., 2010).

Nowadays, environmental and economic concerns are stimulating research in the development of new materials for construction, furniture, packaging and automobile industries. Particularly, many research studies have conducted on composite panels from non wood lingo-

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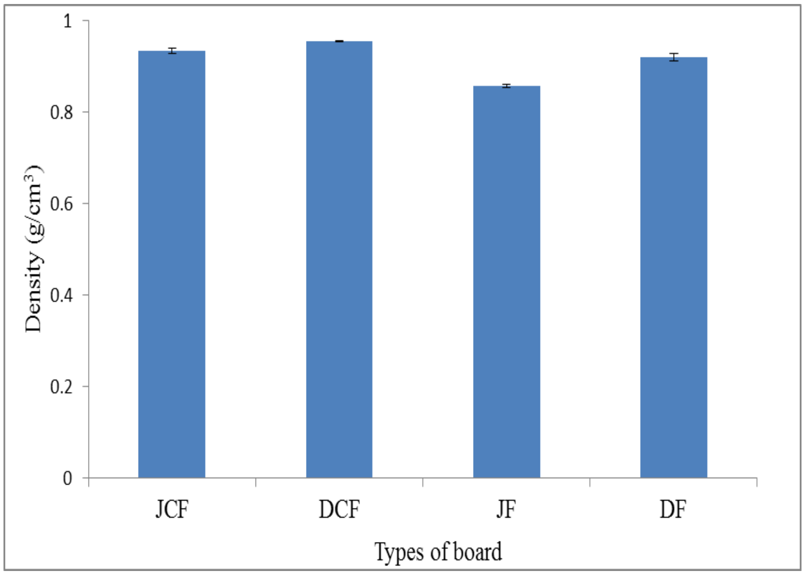

Figure 1. Density of four types of particle board.

Table 1. Summaries of analysis of variance (95% level of significant) of physical properties.

Density	Moisture content (%)	Water absorption (%)		Thickness swelling (%)		Linear expansion (%)		Width expansion (%)	
		Cold water	**After boiling**	**Cold water**	**After boiling**	**Cold water**	**After boiling**	**Cold water**	**After boiling**
Df=3, F=119.85 and P<0.05	Df=3, F=105.22 and P<0.05	Df=3, F=53.55 and P<0.05	Df=3, F=69.82 and P<0.05	Df=3, F=111.53 and P<0.05	Df=3, F=110.33 and P<0.05	Df=3, F=133.33and P<0.05	Df=3, F=125.45 and P<0.05	Df=3, F=112.32 and P<0.05	Df=3, F=154.11 and P<0.05

cellulosic materials in which most are based on natural renewable resources. These resources are abundantly available in many countries, including residues from annual growth crops and plants (Markessini et al., 1997; Rowell, 1998; Chow, 1974). The use of agricultural residues will reduce the pressure on the forest. It will help to optimize use of the material and as well the problem of raw material will be solved. Present world is very concerned about environmental pollution. All the formaldehyde based resin binders are more or less toxic and injurious to health. One of the composite materials that have attracted interest worldwide is the inorganic bonded panels and plastic is used as a binding agent for composite materials.

Considering pressure on forest and environmental aspects, agricultural plastic composite (APC) from jute (*Corchorus olitorius* L) and dhaincha (*Sesbania cannabina*) sticks were studied.

Jute and dhaincha are lingo-cellulosic material, which reduce soil erosion and increase soil fertility having multipurpose uses and fast growing characteristics. They are grown in most of the areas of Bangladesh because of least maintenance and tending operation cost (Pankaj, 2003).

In this study, it was tried to assess the feasibility of APC made from jute and dhaincha evaluating physical and mechanical properties of the two types of board.

MATERIALS AND METHODS

Jute (*Corchorus olitorious*) stems used in this study were grown in Bagerhat (22° 39' 05" N and 89° 48' 11" E), Khulna, Bagladesh and dhaincha (*Sesbania cannabina*) stems were collected from Khulna University (22° 48' 0" N and 89° 33' 0" E), Khulna, Bangladesh. The polypropylene material was collected from Dhaka, Bangladesh.

The barks of both jute and dhaincha were removed from the stems and the sticks were kept in the sun to dry. After drying jute and dhaincha sticks were sawn into small pieces in one inch and in the next these were inserted

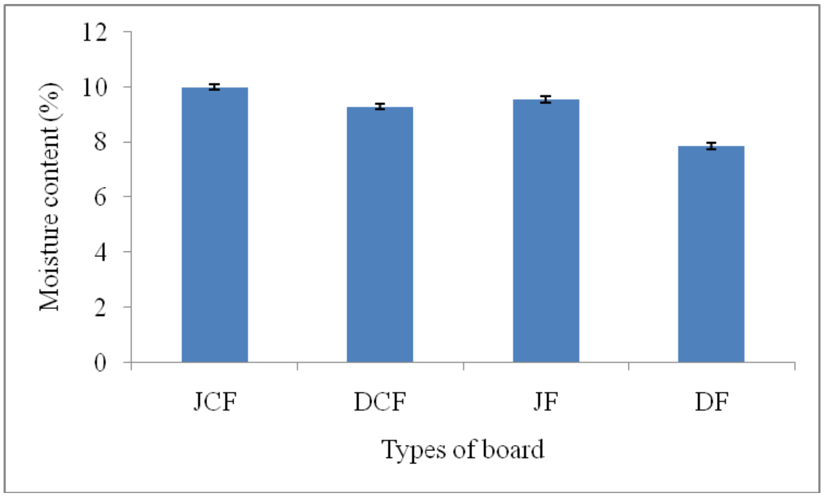

Figure 2. Moisture content of four types of particle board.

separately into the chipper machine having a mesh size of about 8 mm. Each type of the particles was then screened separately by using sieve of 2 mm to separate fine and coarse particles. The screened particles of each type were kept separately in the oven at a temperature of 103^0C for 24 hours to reduce moisture content. The polypropylene material was crashed to reduce its volume.

Four different types of boards viz. jute-fine and coarse mixed (JFC), jute-fine (JF), dhaincha-fine and coarse mixed (DFC) and dhaincha -fine (DF) were manufactured in this study. The mat was formed by fine, corse and fine layer on rectangular of iron mould of a stainless steel plate for JFC and DFC. The polypropylene was mixed with particles properly for every step. For JF and DF, the polypropylene was mixed with particles and single layer mat was formed. The mat of each type was then pressed at 3 N/mm^2 for 15 minutes and the temperature was 140°C. In the next, the boards of each type were trimmed at edges with saw. The thickness of the boards was 7 mm.

Both the physical and mechanical properties were carried out in accordance to British Standard (1989 and 1961). The laboratory tests for characterization of physical and mechanical properties of each type of particleboard were carried out respectively in the laboratory of Forestry and Wood Technology Discipline of Khulna University, Bangladesh and in the Laboratory of Civil Engineering Department of Khulna University of Engineering and Technology, Khulna, Bangladesh. The sample size for physical properties was 30 mm × 24 mm × 7mm whether it was 120 mm × 50 mm × 7 mm for mechanical properties.

All the data, obtained during the laboratory tests for characterization of physical and mechanical properties of each type of particleboards, were analyzed by using Microsoft Office Excel 2007, SPSS (Statistical Package for Social Survey) and SAS (Statistical Analysis System) software.

RESULTS AND DISCUSSIONS

Physical Properties

The density of JCF, DCF, JF and DF was found to be 0.93, 0.95, 0.86 and 0.92 g/cm^3, respectively (Figure 1). The density of four types of board was significantly different (Table 1) with each other. According to NPA (1993), all types of boards manufactured fall into the high density (HD) grade (>0.8 g/cm^3) and according to Indian Standard (Anon, 1985), the density of standard particleboard is between 0.50 to 0.90 g/cm^3. In this study, the density of the boards is similar to the standard of NPA (1993) and Indian Standard (Anon, 1985).

The moisture content of JCF, DCF, JF and DF was respectively 10, 9.30, 9.55 and 7.85% (Figure 2). The moisture content of JCF was higher than that of other types of particles. It has been observed by the statistical analysis that there was significant difference (Table 1) in moisture content among JCF, DCF, JF and DF boards. The maximum moisture content in the standard particle particleboard was not similar to the NPA (1993), Anon (1985) and British (Anon, 1979).

It was found that the absorption of water by JCF, DCF, JF and DF was 18.81, 23.93, 27.45 and 26.35%, respectively after 24 hours immersion in cold water (Figure 3a). After boiling water absorption by JCF, DCF, JF and DF was 67.86, 118.71, 64.09 and 104.35 %, respectively (Figure 3b). JF board had the highest percentage of water absorption for cold water whether it

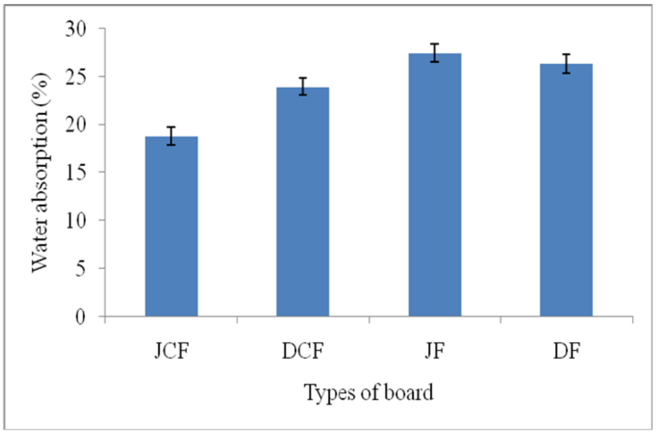

Figure 3a. Water absorption percentages of four types of boards for cold water.

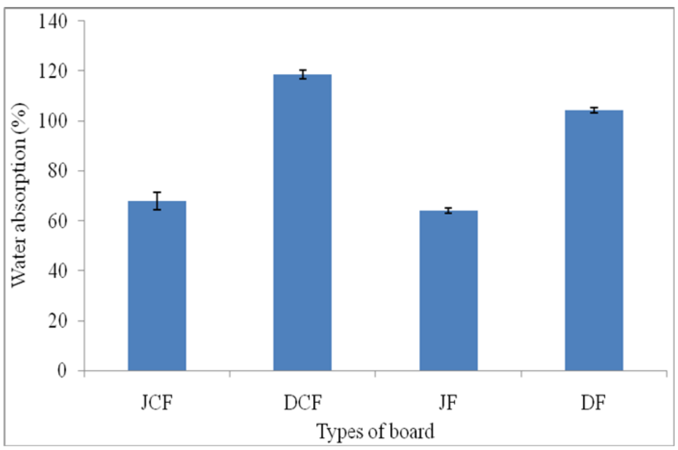

Figure 3b. Water absorption percentages of four types of boards for boiling water.

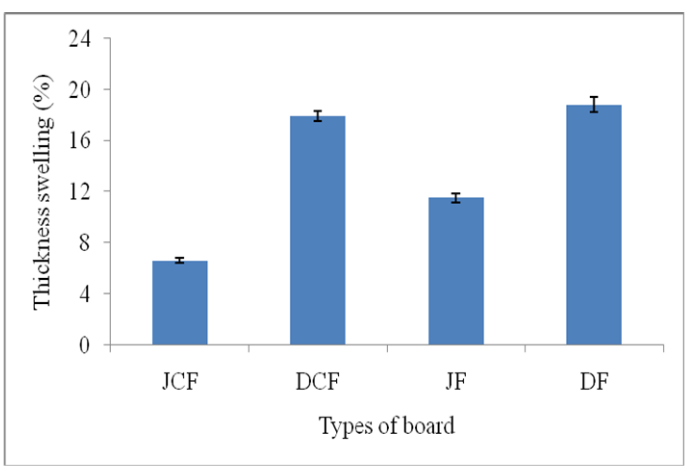

Figure 4a. Thickness swelling percentages of four types of boards for cold water.

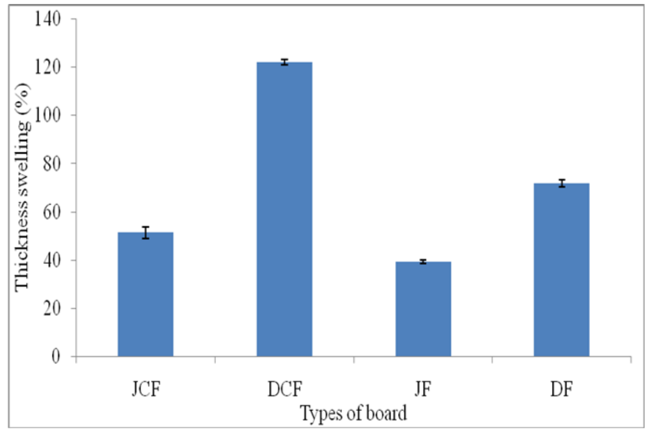

Figure 4b. Thickness swelling percentages of four types of boards for boiling water.

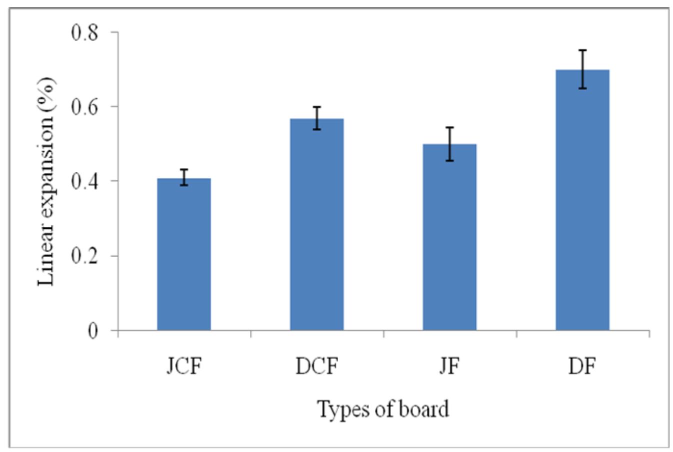

Figure 5a. Linear expansion percentages of four types of boards for cold water.

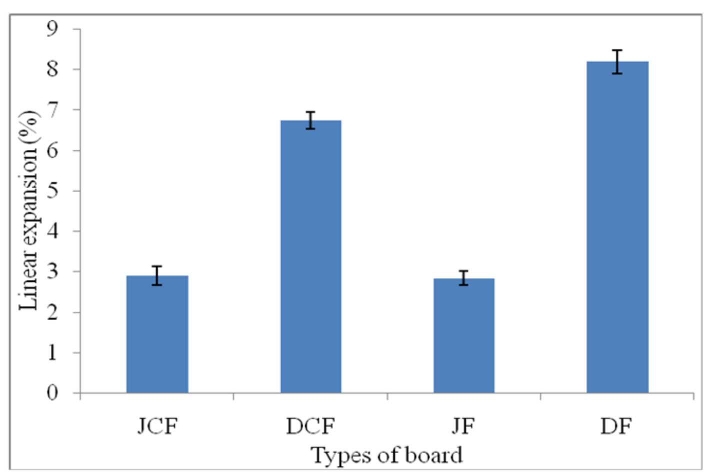

Figure 5b. Linear expansion percentages of four types of boards for boiling water

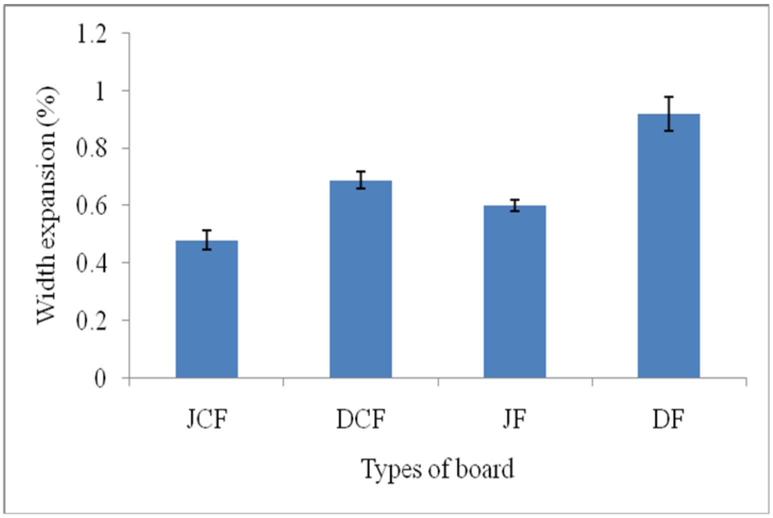

Figure 6a. Width expansion percentages of four types of boards for cold water

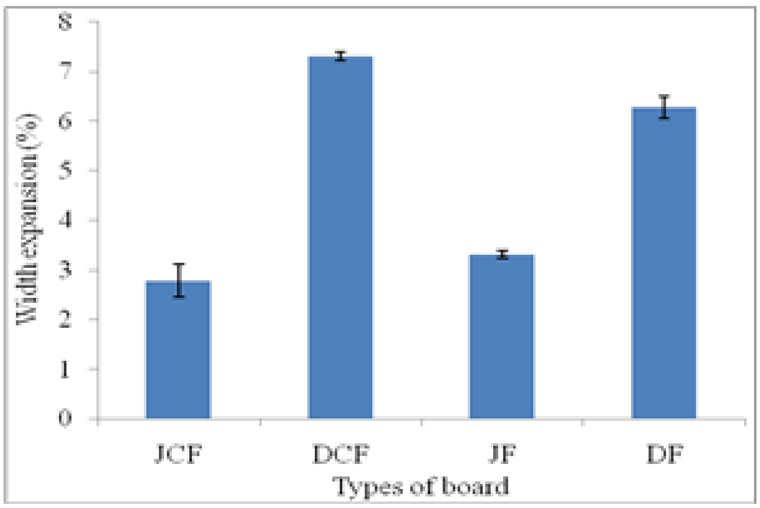

Figure 6b. Width expansion percentages of four types of boards for boiling water.

Particle board was not similar to the NPA (1993), Anon (1985) and British (Anon, 1979).

It was found that the absorption of water by JCF, DCF, JF and DF was 18.81, 23.93, 27.45 and 26.35%, respectively after 24 hours immersion in cold water (Figure 3a). After boiling water absorption by JCF, DCF, JF and DF was 67.86, 118.71, 64.09 and 104.35 %, respectively (Figure 3b). JF board had the highest percentage of water absorption for cold water whether it was the highest for DCF after boiling. Four types of board were significantly different (Table 1) for water absorption for both conditions.

JCF, DCF, JF and DF showed the thickness swelling 6.64, 17.91, 11.53 and 18.80%, respectively as a result of submerging 24 hours cold water (Figure 4a). On the other hand, after boiling 51.32, 121.94, 39.37 and 71.74% were found in JCF, DCF, JF and DF respectively (Figure 4b). The figure shows that DF has the highest thickness swelling than others. Thickness swelling was significantly different (Table 1) among four types of boards for cold and boiling water.

has higher linear expansion than others. Linear expansion 2.90, 6.73, 2.83 and 8.18% were found in boiled samples of JCF, DCF, JF and DF respectively (Figure 5b). By ANSI A208.1–1993 (NPA, 1993), the maximum average linear expansion of standard particleboard is 0.35 %, but the specified time was not found. In this study, linear expansion was higher than that

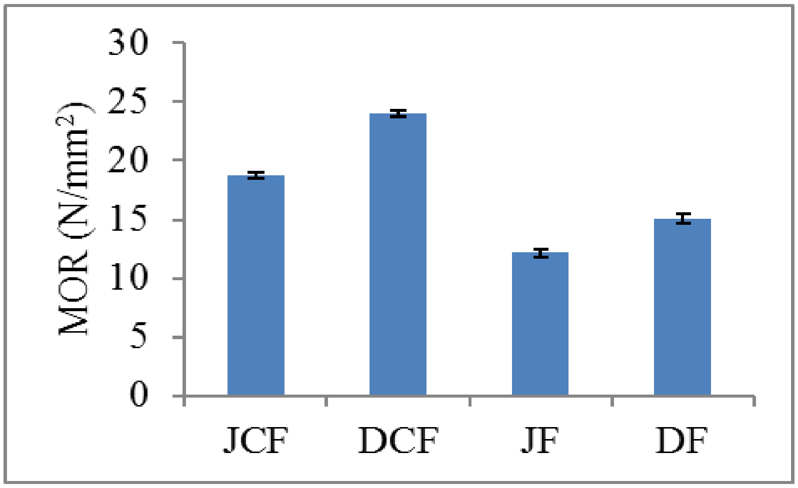

Figure 7a. MOR of four types of board in dry condition.

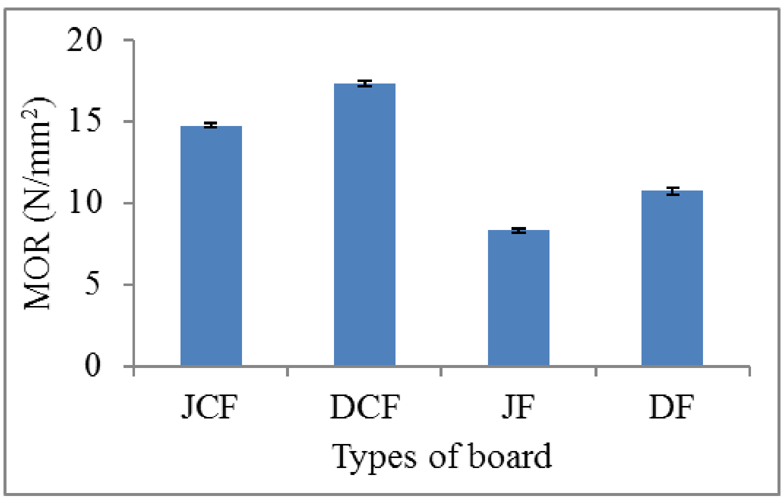

Figure 7b. MOR of four types of board in wet condition.

of standard for immersion in cold and boiling water. Significant difference was found for both conditions among four types of boards by statistical analysis (Table 1).

Figure. 6a shows that the width expansion of JCF, DCF, JF and DF was 0.48, 0.69, 0.60 and 0.92%, respectively after 24 hours immersion in cold water. After boiling, width expansion of JCF, Figure 6a shows that the width expansion of JCF, DCF, JF and DF was 0.48, 0.69, 0.60 and 0.92%, respectively after 24 hours immersion in cold water. After boiling, width expansion of DCF, JF and DF was 2.78, 7.31, 3.31 and 6.27% respectively (Figure 6b).

The DF board has the highest width expansion in both conditions. Significant difference was also found form the statistical analysis among four types of boards for both conditions (Table 1).

Mechanical Properties

In dry condition, the modulus of rupture (MOR) of JCF, DCF, JF and DF was found 18.75, 24.01, 12.14 and 15.04 N/mm² respectively (Figure 7a). The dry MOR of DCF board was the highest. After 24 hours immersion in cold water, the MOR was 14.78, 17.35, 8.31 and 10.75 N/mm² respectively for JCF, DCF, JF and DF (Figure 7b). The highest value of wet MOR was for JCF board. According to ANSI A208.1–1993 (NPA, 1993), the MOR of standard particleboard is 16.50 to 23.50 N/mm² for high

Table 2 Summaries of analysis of variance (95% level of significant) of mechanical properties

MOR (N/mm^2)		MOE (N/mm^2)	
Cold water	**After boiling**	**Cold water**	**After boiling**
Df = 3, F = 68.35 and P<0.05	Df = 3, F = 119.85 and P<0.05	Df = 3, F = 355.58 and P<0.05	Df = 3, F = 319.58 and P<0.05

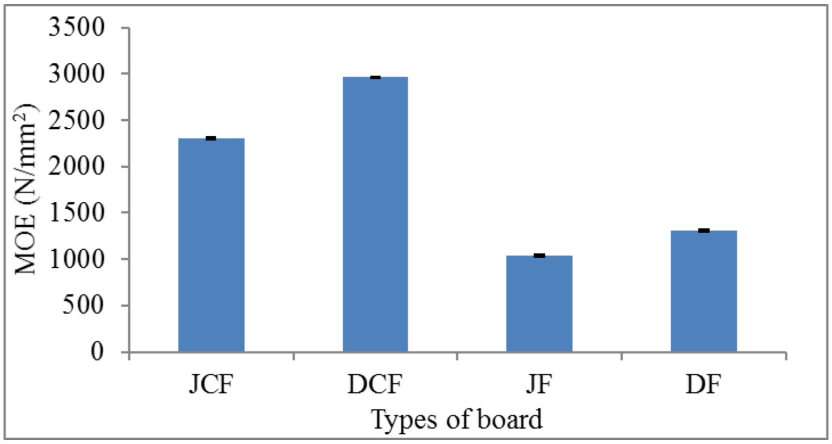

Figure 8a. MOE of four types of board in dry Condition.

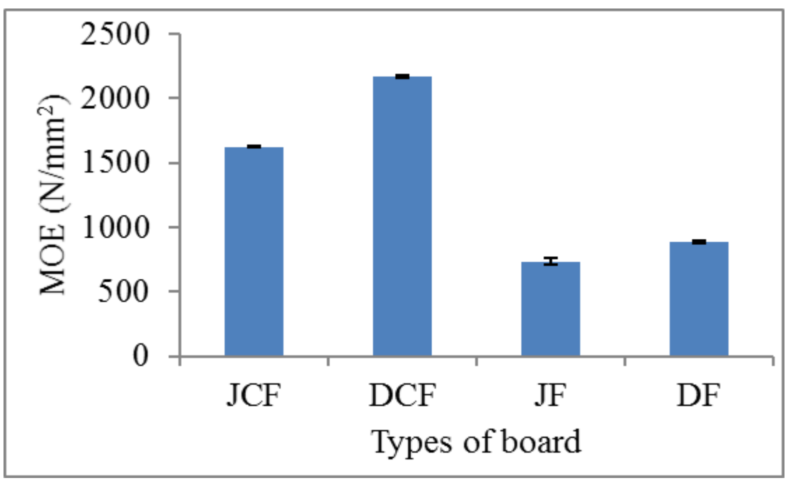

Figure 8b. MOE of four types of board in wet condition.

density grade, 11.00 to 16.50 N/mm^2 for medium density grade and 3.00 to 5.00 N/mm^2 for low density grade. According to IS: 3087-1985 (Anon 1985), the MOR of standard particleboard is 10.98 N/mm^2. According to British Standard BS: 5669 (Anon, 1979) the MOR of standard particleboard is 13.80 N/mm^2 respectively. In dry condition, the MOR of JCF and DCF follow all the standards. From the statistical analysis, it has been noticed that there were significant differences among the four types of boards for dry and wet MOR (Table 2).

The modulus of elasticity (MOE) for dry condition was 2301.05, 2960.85, 1038.17 and 1307.59 N/mm^2 respectively for JCF, DCF, JF and DF (Figure 8a). In case of immerging 24 hours in water, the MOE was observed 1625.24, 2169.38, 737.54 and 889.31 N/mm^2 respectively for JCF, DCF, JF and DF (Figure 8b).

The highest MOE was for DCF in both conditions. ANSI A208.1–1993 (NPA 1993) described that the MOE of standard particleboard is 2400 to 2750 N/mm² for high density grade, 1725 to 2750 N/mm² for medium density grade and 550 to 1025 N/mm² for low density grade. The MOE of DCF of dry condition follows the standard. Statistical analysis showed that there was significant difference among four types of boards for MOE of dry and wet conditions (Table 2).

DCF and JCF showed the best quality in aspect of MOR and MOE.

This two types of board also followed the standard. MOE of JCF did not follow the standard but it was close to the value of standard. It makes the opportunity to use the boards for different purposes

CONCLUSION

It has been observed that all the properties of JCF, and DCF boards meet the requirements of ANSI and IS standards as well as the BS.

Based on the experiment it is also found that, DCF board showed higher MOR and MOE than other boards. All the boards produced from corse and fine of jute and dhaincha show quite satisfactory results.

In future, these types of boards will have a good potentiality to be introduced for commercial purposes.

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