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Suitability of Bamboo (*Dendrocalamus Strictus*) for Preparation of Particle Board

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Key words:

bamboo, particle board, phenol formaldehyde, resin

ABSTRACT

Bamboo is a promising source of lignocellulosic material growing in all parts of our country and it is easily available in large quantities. The experiment was conducted at Forest Products Workshop, Department of Forestry, Dr. P.D.K.V., Akola during 2010-11. The objective of the study was to standardize the suitable percentage of resin for the preparation of board. In this study, phenol formaldehyde bonded particle boards were prepared form Bamboo (*Dendrocalamus strictus*) using hydraulic hot press with resin content viz., 6, 7, 8, 9, 10, 11, 12, 13 and 14 per cent. Subsequently, they were tested for different physical and mechanical properties according to Indian Standard Specification IS: 3087 (1985). The results showed that *Dendrocalamus strictus* is suitable for manufacturing of medium density particle boards. Satisfactory boards were prepared from bamboo using 11 per cent phenol formaldehyde resin met the requirement in respect of physical and mechanical properties as specified in IS: 3087.

INTRODUCTION

Bamboo is one of nature's most valuable gifts to mankind. Its remarkable growth rate and versatile properties have made it one of the most sought after material, especially in tropical countries. It is a fast growing woody raw material for a variety of products in the tropical regions. In India, bamboos constitute important raw materials for use in the pulp, paper, rayon and bamboo mat board industries, besides numerous other traditional uses (Nadgauda et al. 1997). Bamboo is one such lignocellulosic material growing in all parts of our country and it is easily available in large quantities. Initially bamboo was only used in paper and pulp industry and constructional purposes. Then it was successfully tried for making building boards (Narayanmurti and Bist 1948; Narayanmurti 1956; Narayanmurti and Bist 1963 and Dhamaney 1967), Fibre boards (Narayanmurti 1957) hard board (Jain and Dhamaney 1966) and reconstituted wood from bamboo for structural uses (Shukla and Prasad 1988) etc.

Wood and biomass based particle boards find wide applications in construction and furniture industries. The demand for wood based particle boards has increased greatly due to population growth while the timber resources are alarmingly depleted. Therefore, a huge imbalance in the supply and demand for wood based particle board has initiated search for wood substitutes as raw materials for the board industry. Research on alternative plant fibres and agro wastes, recycling and efficient conversion technologies has assumed priority to meet the rapidly increasing demand for boards in future. A number of studies have been conducted for production of particle boards from

agro residues like cotton, sunflower, guar and sorghum stalks, jute stick, tea leaves, date palm, sugar beet leaf fibre, cotton carpel, etc. The physical and mechanical properties of the boards made from the agricultural crop residues meet the requirement of standard medium density particle board.

Particle board finds its use as core material in furniture, store fixture and laminates, sink top and sliding doors. It is widely use in the manufacture of cabinet for TV set, loudspeaker and tape recorder etc. Sound absorption and characteristics of particle board are particularly suitable in this end use. Greater quantity particle board are also used in the automobile construction, sports good, packing cases and for various specialized uses for example bodies of buses, railway coaches, ship building etc. due to low thermal conductivity and good acoustical properties, low density particle board is extensively used in lecture hall etc. the sound absorption and reflection characteristics of low density particle board are particularly suitable for this end use (Shukla and Singh 1994).

The problem of the shortage of the wood as raw material is becoming very severe day by day. There are number of lignocellulosic material which could successfully be utilized for particle board manufacture. Bamboo is one such lignocellulosic material growing in most part of the country and it is easily available in large quantities. Keeping in view above economic importance of the particle board,in this investigation the suitability for *Dendrocalamus strictus* was evaluated for making particle board with the objective to standardize the suitable percentage of resin content for the preparation of particle board from Bamboo as to meet the standard of IS: 3087.

MATERIALS AND METHODS

Freshly felled culms of bamboo (D*endrocalmus strictus*) with the specific gravity of 0.719 gm/cm^3 having moisture content of 76.49 per cent (green basis) were procured from the premises of Department of Forestry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The culms of bamboo were 8 to 9 m in length with diameter and wall thickness varying from 7 to 8.5 cm, 0.5 to 1.0 cm, respectively. The procured clums of bamboo were cross cut into small pieces about 15 cm long in the round form and then the green cross cut bamboos were then further converted into small size about 2 to 3 cm in length on Mini Combiplanner machine. The chips so obtained were than sun dried for 7 to 8 days to bring down the Moisture content about 30 to 40 per cent. The chips were then passed through the wood grinder to obtain particles. The particles passing through 10 mesh sieve were used for preparation of particle board. The screened particles were then sun dried to bring the moisture content about 9.5 per cent.

About 500 gm of dried particle were taken for preparing each particle boards. The dried particle were uniformly blended with different resin content i.e. 6,7,8,9,10,11,12,13 and 14 per cent on the basis of dried particles of bamboo and solid content of phenol formaldehyde resin. The resin blended particles were than air dried so as to bring down the moisture content. Over the cauls plates the mats were made from the resin blended particle. The wooden mould was kept over the caul plates. The resin blended particles were uniformly laid to form mats in a wooden mould. The mats were then pressed in the hydraulic hot press at specific pressure of 300 lbs/inch^2 and temperature of 150 to 155^{0}c for about 12 minutes for making each particle boards. The single layers flat pressed particle boards were made. The size of the boards was 30 x 30 cm in each case.

Particle boards thus obtained were conditioned at room temperature for one week before preparation of test specimens and then tested for various physical and mechanical properties such as thickness variation, density, moisture content, water absorption, length and thickness swelling, swelling due to surface absorption, modulus of rupture, tensile strength perpendicular to surface and screw withdrawal strength as per the procedure laid down in IS: 2380 (Anon. 1977) and IS: 3087 (Anon. 1985).

RESULTS AND DISCUSSION

The data pertaining to the physical properties of particle boards is presented in Table 1.Thickness of the particle board varies from 7.6 mm to 8.5 mm. Moisture content of the board

varies from 5.85 to 12.07 per cent (Fig. 1). All the boards in respect of moisture content met the requirement of the IS specification. Similar type of result has been reported by Nimkar and Singh (2000), Nimkar et al. (2001) in the board prepared from *Bambusa polymorpha.* Bhaduri and Majumder (2008) have revealed that moisture content of the board found within the limit of IS specification.

Density of the particle board varies from 0.69 g/cm^3 to 0.86 g/cm^3 (Fig.2) and the board prepared were in medium density range as per IS:3087 (Anon., 1985). Similar findings have been reported by Singh and Rawat (1990) in the board prepared from Pine saw dust. Nimkar *et al* (2000) also observed same result in the board prepared from *Bambusa polymorpha.* Generally increase in amount of resin increases the density of particle board. The board density is an important parameter correlating strength and acoustical properties of particle board.

The Water absorption test of the boards for 2 hours and 24 hours soaking in water varied from 16.00 to 62.10 per cent and 41.00 to 87.10 per cent, respectively (Fig. 3). Boards prepared with 11 to 14 per cent resin content met the water absorption for 2 hours and 24 hours. Remaining boards did not meet the requirement of specification. With increase in resin content from 6 to 14 per cent, the water absorption values decreased significantly when soaked in water for a certain interval of time. Generally, the amount of resin shows significant effect on water absorption property of the board as reported by various workers (Singh and Rawat 1990; Singh et al. 1995; Nimkar and Singh 2000; Nimkar et al.2001; Bhaduri and Mojumder, 2008).

Length and thickness swelling of the particle boards for 2 hours soaking varied from 0.21 to 0.41 per cent and 6.80 to 20.72 per cent, respectively (Fig. 4). Length swelling of all the particle boards for 2 hours soaking met the requirement of the specification. Thickness swelling of the board exceeded the minimum requirement up to 10 per cent resin content. However, requirement as per the specification was met with the board prepared from 11 to 14 per cent resin content. With increase in resin content, the values for length and thickness swelling of the board decreased when soaked in water for a period of 2 hours. Finding emerged out of this study were in line with the finding given by Beach (1975) who reported irreversible swelling was reduced by increasing the resin content, and reversible swelling was affected by wood species and grain orientation. Differences in length and thickness swelling of particle boards prepared from different resin content has also been reported by Singh and Rawat (1990); Singh and Gupta (1982).

Perusal of data revealed that the range of values for swelling due to surface absorption of particle boards for 2 hours was found to be 6.80 to 19.52 per cent (Fig. 5). The values obtained for swelling due to surface absorption decreases as the resin content increases. The particle board prepared with 11 to 14 per cent resin content met the said property. Other boards could not meet the requirement of the specification. The present findings were in close conformity with those of Singh and Rawat (1990), Singh et al. (1995), Nimkar and Singh (2000) and Nimkar et al. (2001).

The data on mechanical properties of particle boards prepared from *D. strictus* is appended in Table 2. The value of modulus of rupture for various boards prepared using 6 to 14 per cent resin content were much above than those specified (11 N/mm^2) and all the board met the requirement of specification.Increase in the amount of resin content showed further improvement in modulus of rupture values (Fig. 6).

In regards to the tensile strength perpendicular to surface (bonding test), the board prepared with 6, 7 and 8 per cent resin content did not meet the requirement of specification. However, the board's prepared using 9 to 14 per cent resin content on dry weight of the particles met the requirement of the specification. Increasing the amount of resin content, there was further improvement in the values obtained for tensile strength perpendicular to surface (Fig. 6). Present result are supported with the findings given by Satsura (1974), Singh and Gupta (1982), Singh and Rawat (1990), Singh *et al* (1995), Nimkar and Singh (2000), Nimkar et al (2001) and Bhaduri and

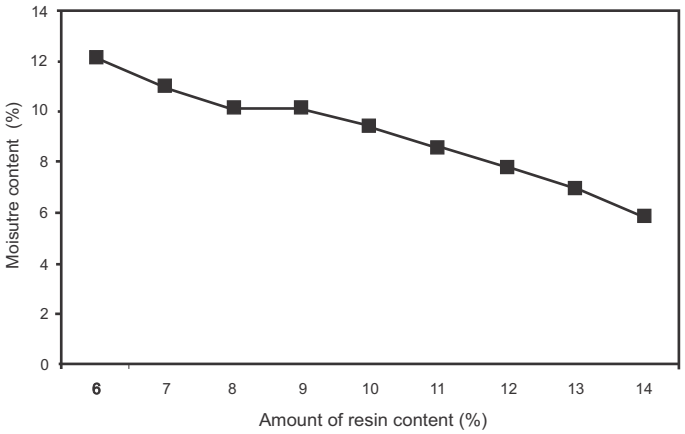

Fig. 1. Relationship between amount of resin content (%) and moisture content (%)

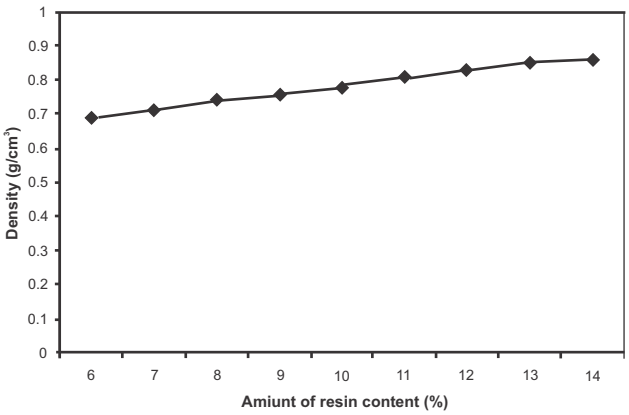

Fig. 2 . Relationship between amount of resin content (%) and density (g/cm^3)

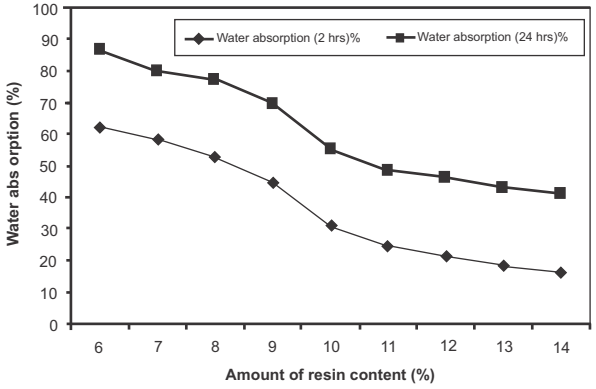

Fig. 3. Relationship between amount of resin content (%) and water absorption (%) in 2 hrs and 24 hrs.

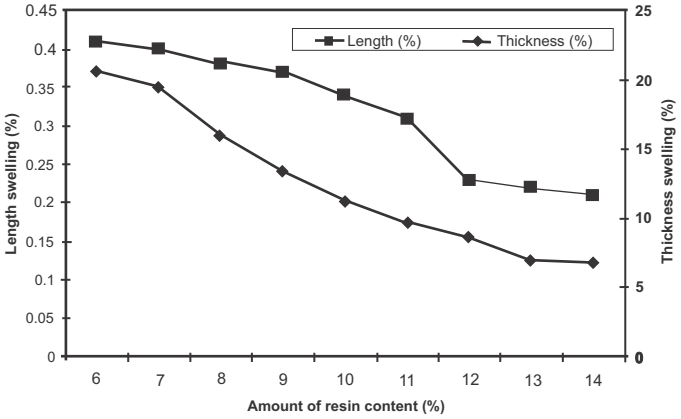

Fig.4. Relationship between amount of resin content (%) and length and thickness swelling (%) in 2 hrs

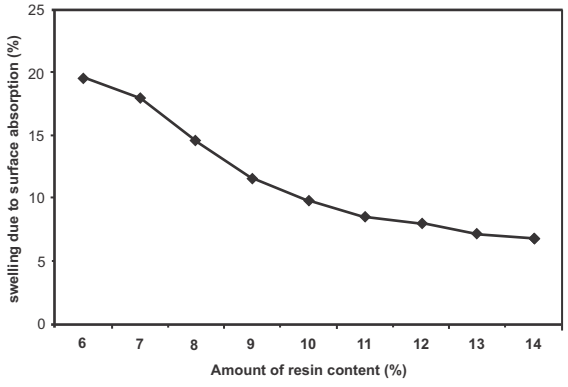

Fig. 5. Relationship between amount of resin content (%) and swelling due to surface absorption (%)

Table 1: Physical properties of particle board prepared from Bamboo (*D. strictus*)

Amo unt of resin used (%)	Thickn ess of the board (mm)	Moist ure content of the board (%)	Density (g/cm^3)	Water absorptio (%) 2 hrs	Water absorption (%) 24 hrs	Length swelling (%) 2 hrs	Thickn ess swellin g (%) 2 hrs	Swelling due to surface absorption (%) 2 hrs
6	8.5	12.07	0.69	62.10	87.10	0.41	20.72	19.52
7	8.4	11.01	0.71	58.07	80.00	0.40	19.53	17.98
8	8.3	10.13	0.74	52.35	77.35	0.38	16.00	14.60
9	8.0	10.10	0.76	44.55	69.55	0.37	13.41	11.55
10	7.9	09.40	0.78	30.70	55.70	0.34	11.25	09.75
11	7.9	08.60	0.81	24.23	48.52	0.31	9.64	08.50
12	7.8	07.80	0.83	21.47	46.47	0.23	8.66	08.00
13	7.7	06.90	0.85	18.24	43.24	0.22	7.04	07.13
14	7.6	05.85	0.86	16.00	41.00	0.21	6.80	06.80
Requirement of IS:3087 (1985)		5 to 15	0.5-0.9	**≤25**	≤50	≤0.50	≤10	≤09.00

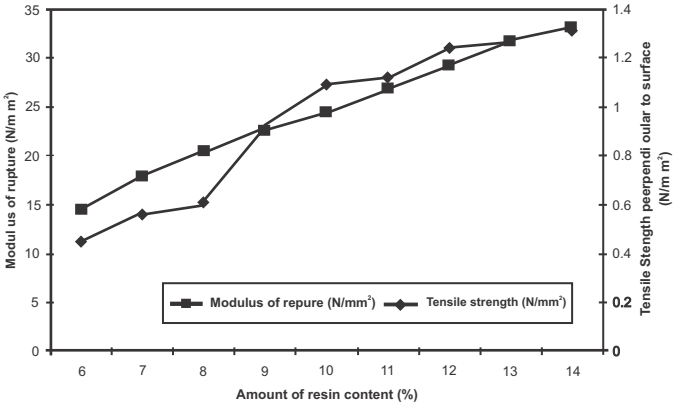

Fig. 6. Relationship between amount of resin content (%) and modulus of rupture (N/mm^2) and tensile strength perpendicular to surface (N/mm^2)

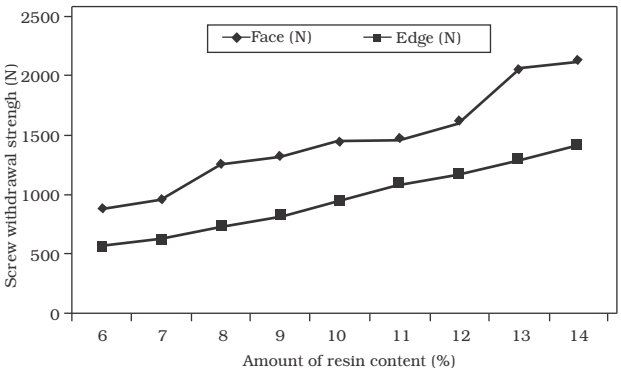

Fig. 7. Relationship between amount of resin content (%) and screw withdrawal strength (N)

Table 2: Mechanical properties of particle board prepared from Bamboo (*D. strictus*)

Amount of resin used (%)	Modulus of rupture (N/mm^2)	Tensile strength perpendicular to the surface (N/mm^2)	Screw withdrawal strength (N)	
			Load at f ace surface	Load at e dge surface
6	14.42	0.45	890	560
7	17.87	0.56	965	629
8	20.45	0.61	1270	738
9	22.55	0.92	1326	820
10	24.37	1.09	1456	959
11	26.88	1.12	1478	1094
12	29.25	1.24	1620	1174
13	31.62	1.27	2058	1296
14	33.10	1.32	2130	1421
Requirement of IS:3087 (1985)	11	0.9	1250	850

Mojumder (2008).

The values recorded for screw withdrawal strength at face and edge surface varied from 890 to 2130 N and 560 to 1421 N, respectively (Fig. 7). At face surface, the boards prepared with 8 to 14 per cent resin content met the requirement of IS specification whereas the boards prepared with 10 to 14 per cent resin content met the requirement of specification in case of edge surface. The present investigations were in conformity with the findings reported by Shyamasunder and Victor (1972), Singh et al. (1995), Nimkar and Singh (2000) and Nimkar et al. (2001).

From the above investigations, it is concluded that Bamboo (*D. strictus*) is a suitable raw material for making particle board. The boards prepared with 11 per cent resin content meets the requirement of the IS: 3087 (1985) specification for medium density particle board.

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