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SUITABILITY OF HYBRID ACACIA WOOD FOR MANUFACTURING PLYWOOD AND PARTICLEBOARD

M. M. RAHAMAN, K. AKHTER, D. BISWAS AND M.W. SHEIKH

Veneer and Composite Wood Products Division, Bangladesh Forest Research Institute, Chittagong, Bangladesh

ABSTRACT

Hybrid acacia, produced from natural crossing between two introduced timber species *Acacia mangium* and *A. auriculiformies* has been studied for assessing the suitability of plywood and particleboard manufacture. It was found that 1.5 mm thick smooth and figured veneer can be made and dried easily. Three-ply plywood were made using veneer of this species bonded with liquid urea formaldehyde glue of 50% solid content extended with wheat flower and catalyzed (ammonium chloride) with 2% hardener under the specific pressures, *viz.*, 1.05, 1.40 and 1.76 N/mm^2 in three replications at 6 minute press time and 120^oC press temperature. Dry and wet shear test were conducted on the sample and their shear load at failure per unit area and percentage of wood failure were determined. 1.76 N/mm^2 pressure for the manufacture of ply wood is found to be the best. The particleboard was tested for determining the strength and dimensional stability. The bending strength passed the standard specification, tensile strength was found to be low as per Indian standard.

Key words: Particleboard, Modulus of rupture, Internal bond strength, Hardener

INTRODUCTION

The forests of Bangladesh have nearly 500 hard wood species but about 55 species are at present being used for the manufacture of different composite wood products (Anon. 1984), 16 species of timber are commonly used for decorative plywood (Anon. 1986), 36 species are used for plywood and battens for tea-chest (Anon. 1979a), 46 species for manufacture of plywood for general purposes (Anon. 1983), 17 species for marine ply wood (Anon. 1985a) and 5 species are used for manufacture of particle board at Bangladesh Forest Industries Development Corporation (BFIDC), Kalurghat, Chittagong (Anon. 1981). There are more than 20 plywood and three particleboard factories operating in Bangladesh (Kibria *et al.* 2000). These industries are dependent on those limited number of species.

Hybrid acacia was discovered in road side stands in Malaysia (Pinso and Nasi 1991). Four years later, Tham (1976) documented that *Acacia mangium* and *A. auriculiformies* can cross pollinate, resulting in a hybrid acacia that grows much faster than their parents. Comparative growth study on the tree species has been conducted by Kamaluddin and

Rahaman (1995) on 4.5 years old plantations raised at Madhupur Forest Range of Tngail Forest Division in Bangladesh, though hybrid acacia shows outstanding performance, information about its performances in variety of sites (Newaz 1998). *A. mangium* and *A. auriculiformis* were introduced in Bangladesh as shade tree in tea gardens about 40 years ago. The hybrid acacia also showed more resistance to heart rot disease, a disease that occurs in *A. mangium* and it was observed that the species grows vigorously resisting heart rot disease in the forest plantations (Banik and Islam 1996). In 1980s provenance trials of these species have been established at different Silvicultural Research Stations (SRS) of Bangladesh Forest Research Institute (BFRI). Thousands of hectares of plantations with these two species have been raised by Bangladesh Forest Department (FD). In recent years, naturally crossed hybrids of *Acacia auriculiformis* and *A. mangium* have been found in the plantations of these species in Bangladesh. Since 1995, such hybrid acacia trees were selected and propagated by using shoot cutting for establishing a hedge orchard. Copies shoots sprouted from this hedge plants were used as stem cutting for rooting trials and successful cutting from different clones provided planting materials for clonal trial experiment (Gani *et al.* 2001). Although this species is used in furniture and plywood industries, information regarding its peeling and gluing properties is not adequately known.

The gluing characteristics of many introduced timber species of Bangladesh are not known. Adequate knowledge of the gluing characteristics is essential for optimum utilization of the timber resources by the respective industries, like the plywood and laminated wood. Gluability is a function of wood, its structure, presence of extraneous materials etc. The present study was undertaken to find out the peeling and gluability of hybrid acacia veneer in the manufacture of plywood and particleboard.

MATERIAL AND METHODS

Defects free and straight bole logs of hybrid acacia (cross pollinate *Acacia mangium* and *Acacia auriculiformies*) were collected from the Bangladesh Forest Research Institute campus. These were crosscut to 1.25 m bolts. The diameter of log was 0.4125 m. These were submerged under water in the soaking tank to saturate with moisture and to avoid fungal and insect attacks. The bolts were peeled to 1.5 mm target thickness in a Coe-Veneer Lathe machine with knife angle at 91°-15". Recovery of veneer was calculated. Veneer thickness, veneer quality, grain pattern, colours, smoothness, etc was observed carefully. The moisture of the green veneer was found out by moisture determination balance. The green veneers were dried in the industrial batch oven to 8% moisture content. The randomized sheets of 500 mm × 500 mm veneers were used to determine the percentage shrinkage in three directions, *viz.*; longitudinal, tangential and

radial. The dried veneer was used for gluing studies. The veneer was clipped to 600 mm × 600 mm. Liquid urea formaldehyde glue of 50% solid content, catalyzed with 2% ammonium chloride and extended with 20% wheat flour was used to prepare 3-ply plywood. The plywood panels were manufactured at three specific pressures *viz.*, 1.05, 1.40 and 1.76 N/mm^2, applying 6 minutes press time for each specific pressure and a constant temperature of 120^{o}C. These were conditioned at 65±5% relative humidity and 20 ± 2^{o}C temperature. The dry shear tests of the plywood were measured. The wet shear tests were measured by soaking the samples for 24 hours in cold water. The shear load at failure and the percentage of wood failure were determined. The wastage of dry veneer was hammer milled to chips and seived through 20 mesh screen to remove dust and fines. The chips were dried to 4 to 5% moisture content. Five-single layer particleboard of size 500 mm × 500 mm × 12 mm having a target density of 750 kg/m^3 were made in the laboratory hot press. The temperature of the platens of the hot press was maintained at 140^{o}C. Ten per cent solid content of liquid urea formaldehyde glue based on oven dry chips was used in the particleboard manufacture. The liquid urea formaldehyde was catalyzed with 2% ammonium chloride. The mats of the board were formed manually in wooden fabricated bordered frame. Then the mats were pressed initially at 3.56 N/mm^2 for 6 minutes. The pressure was then lowered in two steps, firstly 1.05 N/mm^2 for 4 minutes and then 0.35 N/mm^2 for 2 minutes. The boards were then conditioned at 65 ± 5% relative humidity and 20 ± 2°C temperature before they were put to tests.

The particleboards were cut into tests specimens. The static bending tests (modulus of rupture in bending) was carried out according to Indian specification of IS: 2380 (Anon. 1977) with a constant loading speed of the testing machine at 12 mm/minutes. The tensile strength perpendicular to the surface was also carried out according to the Indian specification of IS: 2380 (Anon. 1977) with the exception that wooden blocks of 75 mm × 25 mm were glued in cold press with the test specimens. Three specimens of size 100 mm × 100 mm were taken from each board for determining thickness swelling and water absorption. The thickness of the specimens was measured with the platform type thickness gauze with an accuracy of 0.01 mm. The test specimens were immersed in 25 mm depth of cold water. At the end of 2 and 24 hours, the test specimens were withdrawn from water, wiped with a damp cloth, re-weighed and re-measured the thickness as before. The percentage of water absorption and thickness swelling were then calculated.

RESULTS AND DISCUSSION

The results of peeling studies of hybrid acacia including veneer characteristics and relative suitability of veneer are given Table 1. The bolt was almost cylindrical, with no

natural defects. The bolts were peeled smoothly and no fuzziness of the veneer was observed. The surface of the veneer sheet was smooth and no raising of grains were seen. The veneer peeled readily and easily. The result of drying and shrinkage of veneer are given in Table 2. Veneers dried easily and the surface of veneer looked very smooth. The load at failure of dry and wet shear test and the percentage of wood failure at three specific pressures, *viz*, 1.05**,** 1.40 and 1.76 N/mm^2 are given in Table 3. Maximum wood failure found in dry shear test was 96% at 1.76 N/mm^2 specific pressures indicating strong bonds, but after 24 hour soaking in cold water (ambient condition), the sample gave maximum wood failure (45%).

Table 1. Result of peeling study of hybrid acacia.

Pre-treatment	Ease of cutting	Veneer characteristics	Veneer recovery (%)	Relative suitability		
				Commercial	Decorative	Inner ply
Log was peeled at cold condition	Peeled easily	Sapwood cream colored, heartwood chocklet brown, veneer straight grain, smooth and no fuzziness. Lightly sour odour	50 - 60	Well	Well	Well

Different physical and mechanical properties of particleboard made with the chips of hybrid acacia and the different standards are shown in Table 4. Franz *et al.* (1975) pointed out that modulus of rupture is the most important mechanical property of particleboard with respects their particle application as structural elements. Medium density particle board has the highest bending strength than those given in the Indian, British and German standards. The tensile strength is higher than German and British standards but does not meet the requirement of Indian standard. The tensile strength indicates stronger bonding property.

Table 2. Shrinkage properties of dried veneer at 8% target moisture content.

Average green moisture content (%)	Shrinkage (%)			Remarks
	Tangential	Radial	Longitudinal	
46	5.45	4.73	0.32	Veneers were dried easily but when sun dried, warping of veneer occurred

Thickness swelling and water absorption of hybrid acacia meet the demand of the Indian standard. On the other hand, the thickness swelling values after two hours immersion did not confirm the German standard.

Table 3. Results of gluing studies of hybrid acacia.

Test	Specific pressure of plywood manufacture					
	1.05 N/mm^2	Sd	1.40 N/mm^2	Sd	1.76 N/mm^2	Sd
Average load at failure of dry shear test (N/mm^2)	2.73	3.23	2.76	3.66	2.83	2.35
Percentage of wood failure of dry shear test	87	–	88	–	96	–
Average load at failure of wet shear test (N/mm^2)	1.80	4.00	1.81	4.77	1.95	2.83
Percentage of wood failure of wet shear test	40	–	45	–	45	–

Table 4. Physical and mechanical properties of particleboard made from hybrid acacia.

	Thickness of particle board (mm)	Density of particle board (kg/m^3)	Modules of rupture (N/mm^2)	Tensile strength (N/mm^2)	Thickness swelling (%)		Water absorption (%)	
					2 hr	24 hr	2 hr	24 hr
Standards compared with	14.8	Av. 759 Sd. 14.00	Av.22.0 Sd.42.90	Av.0.78 Sd.0.87	Av. 7 Sd.1.25	Av. 20 Sd.6.77	Av. 20 Sd.3.94	Av. 35 Sd.7.43
IS specification 3087 (Anon.1985)	6 - 40	500 - 900	11.20	0.8	10	–	25	50
German standard Din 68761 (Verkor1975)	13 - 20	600 - 750	18.00	0.35	Max. 6	–	–	–
BS specification 5669 (Anon.1797)	6 - 19	–	14.00	0.347	2 (for 1 hr soaking)	–	–	–

CONCLUSIONS

Hybrid acacia peels easily and produces the best quality veneer which can be used for decorative purpose, plywood for general use and particleboard made from chips can also be used conventionally.

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