Suitability of *Albizia falcataria* Wood for Cement Bonded Particleboard

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Abstract

Albizia falcataria wood has been studied for the suitability of manufacturing cement bonded particleboard. This species failed to produce board in workable conditions with the untreated chips. A substantial improvement of properties was observed when the boards were made with the chips treated in cold water. The boards were tested for determining the strength and dimensional stability. The product was found to be dimensionally stable after soaking in water. Even though bending strength was found to be low, the tensile strength passed the standard specification. Cement bonded particleboard made with this species can be used where dimensional stability is necessary.

সারসংক্ষেপ

সিমেন্ট বন্ডেড কুঁচিতক্তি তৈরীকরণের উপযুক্ততা যাচাইয়ের জন্য আলবিজিয়া ফ্যালকাটারিয়া (*Albizia falcataria*) প্রজাতির উপর পরীক্ষা চালানো হয়। কাঠের অপ্রক্রিয়াজাত কুঁচি দিয়ে কাজোপযোগী বোর্ড তৈরী করা সম্ভব হয়নি। কিন্তু কুঁচিগুলো ঠাণ্ডা পানিতে প্রক্রিয়াজাত করার ফলে বোর্ডের শক্তি সম্বন্ধীয় গুণাবলী অনেকাংশে বেড়ে যায়। শক্তি ও আকৃতিক স্থায়িত্ব নির্ধারণের জন্য বোর্ডগুলো পরীক্ষা করা হয়। দেখা যায়, পরীক্ষার জন্য তৈরী নমুনাগুলো পানিতে চুবানোর পর আকৃতিগত দৃঢ়তা বজায় রাখে। যদিও বক্রতার শক্তি কম কিন্তু টানশক্তি স্টাণ্ডার্ড স্পেসিফিকেশনের শর্ত উপযোগী। যেখানে আকৃতিগত স্থায়িত্বের প্রয়োজন, সেক্ষেত্রে এই প্রজাতির সিমেন্ট বন্ডেড কুঁচিতক্তি ব্যবহার করা যেতে পারে।

Key words : Dimensional stability, inorganic binder, particleboard, portland cement

Introduction

Cement bonded particleboard (CBP) is a composite panel manufactured with portland cement as an inorganic binder. Particleboard bonded with an organic binder, specially urea formaldehyde, has limited application due to its poor resistant against humid weather. Now-a-days, CBP has become more accepted because it is virtually incombustible, durable, and highly resistant against weather. One major limitation in the manufacture of CBP, however, is the variability in developing bond between cement and various wood species containing chemical substances that inhibit setting of the cement binder. Some research works (Biblis and Lo 1968, Moslemi *et al.* 1983, Zhenglian and Moslemi 1986) indicate that the problem of interference of these chemicals with cement setting can be reduced by adopting different measures such as cold and hot water extraction of wood, yard storage of raw material and use of chemical additives in the furnish.

Currently, there are over 38 CBP plants in operation throughout the world (Moslemi 1989). An extensive development of CBP industry has taken place throughout the world during 1980-90 when 12 plants were established in Soviet Russia, five in Japan, two each in Germany and Turkey, and one each in Malaysia and Thailand. Stillinger and Wentworth (1977) pointed out that in tropical and subtropical countries, the problem of building low cost dwelling houses that would withstand extreme climatic conditions and last long can be solved by using high density wood-cement board.

Bangladesh is a densely populated country. The problem of housing is becoming more and more acute with the increase in its population. Moreover, natural disasters like flood are very frequent, and humid weather prevails in most part of the year. The situation, therefore, demands low-cost housing for the teeming millions that would very likely promote the use of CBP panel as cheap construction material. In this context, the present study was undertaken to evaluate the suitability of *Albizia falcataria* in the fabrication of cement bonded wood composites.

Materials and methods

A log of *Albizia falcataria* was peeled to 1.5mm thick veneer. Before converting the veneer into particles, all identifiable defects (e.g. knots) were removed. The veneers were then hammermilled to chips and sieved through 20 mesh screen to remove dust and fines. These were then soaked in cold water for 48 hours and dried to 12-14% moisture content. Particleboards were made with these chips at a density of 1000 kg/m^3 using wood cement ratio of 30:70 at 45% mat water content. Ordinary portland cement collected from the local market was used.

Measured quantity of wood chips and cement were taken to which 2% $CaCI_2$ (on the weight of cement) was added to increase the compatibility of the chips with cement. $CaCI_2$, mixed with water, was added to wood and cement which were then thoroughly mixed by hand until a uniform mixture was obtained. Mat was formed manually in a 50cm x 50cm wooden frame and cold-pressed to a target thickness of 12mm applying 140 PSI pressure for 24 hours. The panels were then stripped off the caul plates and kept vertically for three to four weeks for final curing. Samples were prepared from five replicate boards and conditioned at 65 ± 5% relative humidity and 20 ± 2^{o}C temperature until a uniform moisture content of about 9 to 10% was attained. Tests were performed according to BS 5669 part 1 : 1989. Thickness swelling and water absorption were determined after prolonged soaking in water for 27 days.

Results and discussion

Attempt was made to make particleboards with untreated chips but it failed to produce workable boards. The untreated chips showed too poor bonding with cement and they could be easily scratched off the panel. A cold water solubility test performed on the chips showed that they contained 2.97% soluble ingredients that could have inhibited the curing of cement (Akhter 1995). These substances generally include tannins, gum, sugars, organic salts, cyclitons, galactons and pectin like materials present in wood (Browning 1967). Several investigators mentioned that substances like simple sugars, sugar acids and hemicelluloses and extractives (phenol and tannins) inhibit curing of cement (Hachmi and Campbell 1989, Weatherwax and Tarkow 1967, Zhenglian and Moslemi 1985). According to Rahim *et al.* (1987) sugars such as sucrose, glucose and fructose have significant adverse effect on cement setting even at 0.4% concentration. It seems that the poor bonding of cement with the untreated chips was due to the presence of organic materials which poisoned the cement hydration. The amount of soluble chemicals in untreated chips was reduced by 2.19% by cold water extraction for 48 hours. This greatly improved the wood-cement bond, and consequently produced reasonably good panels.

The result of strength tests of these panels with a comparison with the British Standards Specification (BS 5669) is given in Table 1. Dimensional stability of the boards is shown in (Table 2). The panels possess high tensile strength perpendicular to the surface which are in the range of 5.44 to 6.52 kg/cm^2 (Table 1). These are at par with the values mentioned in the British standard both for the two grades of board, namely T_1 (low to moderate rate of performance in the presence of moisture) and T_2 (high level of performance in the presence of moisture). On the other hand, the bending strength of the panel is lower than the acceptable limits. The average bending strength value was observed to be 59 kg/cm^2 with the maximum being 66 kg/cm^2 and the minimum 51 kg/cm^2. This is approximately 50% lower than the recommended value. Badejo (1988) found that both flake dimension and board density are important factors that control the bending strength. He reported maximum mean MOR of 11.15 N/mm^2 for panels made of density level 1200 kg/m^3 with the longest flake length of 37 mm and a smaller thickness of 0.25 mm, and 5.22 N/mm^2 for panels produced from 1050 kg/m^3 density level and with 12.5 mm long and 0.50 mm thick flakes. He also reported that like resin bonded particleboard, longer and thinner flakes produce CBP of higher MOR. In the present investigation, the mean MOR values of 5.9 N/mm^2 is obtained for the panels fabricated at 1000 kg/m^3 where chips dimensions were about 29 mm long and 0.95 mm thick. So it closely agrees with Badejo's observation.

Panel fabricated at higher density generally exhibits higher bending strength. Kuroki *et al.* (1993) pointed out that low board density (1000 kg/m^3 or below) would not result in property levels that are highly desired. He also stated that in order to achieve a bending strength of 120 to 130 kg/m^2 the density has to be increased to 1150 kg/m^3. In a case study prepared for the FAO (Anon. 1975), it is reported that the bending strength of the board at density level 1000 kg/m^3 and a wood cement ratio of about 1:1.8 is approximately 25% lower than the recommended standard value. It may, therefore, be inferred that the bending strength as observed in this study could be improved by increasing the density of the panel and by using longer and thinner flakes.

Table 1. **Strength properties of cement bonded particleboard made from cold water extracted *Albizia falcataria* chips.**

Property	Mean	Max.	Min.	SD	Standard requirement	
					T_1	T_2
Density (kg/m^3)	976	996	945	20.69		
Thickness (cm)	1.31	1.35	1.28	0.024	0.6-40	0.6-40
Static bending strength (kg/cm^2)	59	66	51	6.56	100	100
Tensile strength (kg/cm^2)	6.02	6.52	5.44	0.52	5	4.5

T_1 = CBP that has only low to moderate levels of performance in the presence of moisture.

T_2 = CBP that has very high levels of performance in the presence of moisture.

Table 2 . Dimensional stability of cement bonded particleboard after prolonged soaking in water.

Water Soaking time	Water absorption (WA, %)				Thickness swelling (TS,%)				Standard requirement for TS	
	Mean	Max	Min	SD	Mean	Max	Min	SD	T_1	T_2
1 hour	16.3	17.5	14.9	1.00	2.25	2.65	1.77	0.38	3	1.5
2 hour	20.2	21.2	19.1	0.88	2.45	2.83	1.83	0.39	-	-
24 hour	27.8	29.5	25.7	1.64	2.87	3.29	2.83	0.36	12	1.8
3 days	32.9	35.3	29.9	2.13	3.15	3.63	2.44	0.44		
6 days	36.6	39.0	33.4	2.33	3.40	4.10	2.56	0.56		
9 days	40.4	42.8	37.4	2.34	3.62	4.36	2.74	0.58		
27 days	46.5	49.3	43.6	2.26	3.88	4.63	2.98	0.59		

The average values of water absorption and thickness swelling after prolonged soaking in water for 27 days ranged from 16.3 to 46.5% and 2.25 to 3.88% respectively (Table 2). These values fall within the range (mean water absorption, 28.1 to 65.8% ; thickness swelling, 0.67 to 4.22%) reported by Prestemon (1976) for 25mm thick CBP boards made from sawdust of oak and elm following 24 hours water soaking. This indicates that the results ascertained in this study (after prolonged soaking for as many as 27 days) are highly satisfactory.

Table 2 shows that thickness swelling increases initially with soaking time. Maximum increase in thickness took place in the first one hour after which the rate of increase reduces. By comparing the results specified in the standard, it was observed to be much better than T_1 board but slightly inferior to T_2 board in the same condition.

Albizia falcataria is a low density species. Medium density (0.7gm/cm^3) particleboard of this species (bonded with urea formaldehyde glue) showed high thickness swelling (about 29%) after 24 soaking hours (Ali 1983). Given the same soaking period, the particleboards (bonded with portland cement) was found to swell by only 2.9%, and with no tendency to delaminate after 27 soaking days. This implies that cement bonded particleboard made from this species would be a resistant and dimensionally stable product against humidity.

Conclusion

The study indicated the potential of *Albizia falcataria* for the manufacture of cement bonded particleboard. The water soluble chemicals present in the species that may inhibit the setting of cement, however, should be removed by cold water extraction. The tensile strength and the thickness swelling property of the board were observed to meet the standard but rather low in bending strength. This property, however, could be compensated by increasing the density level and by using longer and thinner flakes.

Acknowledgements

The authors are thankful to M. S. Khan for his valuable suggestions in the preparation of manuscript. Utmost thanks are extended to M. Mahabubur Rahman for necessary assistance in conducting the experiment and also thanks to Mrs. Shaheda Akhter for making tables and typing.

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