Research Journal of Agriculture and Forestry Sciences _____E-ISSN 2320-6063
Vol. **4(11),** 1-4, November **(2016)** *Res. J. Agriculture and Forestry Sci.*

Short Communication

Effect of Cement: Bamboo Particle Ratios on Physical and Mechanical Properties of Cement Bonded Particle Board

Manish Ranjan* **and D.P. Khali**
Composite Wood Discipline, Forest Products Division, Forest Research Institute, Dehradun, India
manishranjan509@gmail.com

Available online at: www.isca.in, www.isca.me
Received 22nd September 2016, revised 29th October 2016, accepted 5th November 2016

Abstract

In this study Bamboo (Dendrocalamusstrictus) particles were taken for making cement bonded particle boards. Portland cement was used as a sizing agent. The amount of bamboo particles was taken on air-dry basis. Different proportion of cement/bamboo particle ratios 2.0:1.0, 2.5:1.0, and 3.0:1.0 were used for study of physical and mechanical properties of cement bonded particle board. 2% of sodium silicate and 2% aluminum sulfatewere used forpreventinghydration and increasing the rate of cement setting. 28kg/cm^2 pressure were used for preparation of 10mm thick board. The results showed that physical properties of the board decreases with increase in cement: bamboo particle ratios and the mechanical properties of the board increases with increase in cement: bamboo particle ratios.

Keywords:

Introduction

Wood based panel products are important material for variety of domestic, commercial and industrial applications. Forest, which was the main source of woody raw material for manufacture of such products, cannot be exploited any further now as they play a vital role for environmental stability; ecological balances as well as carbon sink of the country[1].

Plantation wood is therefore, now being used by the panel product industries as raw material in a big way. But still there is an ever increasing gap between demand and supply of wood due to population explosion, improved standard of living and diversified industrial activity in the country. Use of alternate raw material for manufacture of panel products is therefore, need of the hour.

Mineral-bonded wood products were initially developed in Europe nearly half a century ago. The first product was magnesite-bonded light weight wood wool (excelsior) board, which was later modified to adopt Portland cement as a binder[2,3]. Building products, such as cement bonded particle board (CBPB), wood wool cement board (WWCB), cement bonded fiberboard (CBFB), etc., made from mineral binding materials and wood aggregates are widely applied in many developing countries.

Recently there has been a spur in interest, in the commercial manufacture of cement-bonded composites from agriculture and wood residues in the developing countries for low cost housing projects. These boards possess the advantage of inorganic and organic materials. Other desirable characteristics include fire resistance and durability in warm, humid climate where decay and termites are a major concern[4].

Because of the versatile nature the boards found large scale application in low cost housing, shuttering, sandwich type boards for insulation, ceilings etc. They are superior in physical properties such as thermal conductivity, sound absorption and possess adequate strength and excellent working qualities. Cement bonded particle boards are classified as class-I fire resistant materials based on surface spread on flame test. All these factors have contributed significantly to the adoption of this material in low cost housing and construction of industrial and commercial complexes.

Therefore, present work was being carried out to examine the compatibility of lignocellulosic fast growing Bamboo particle for bonding with cements of varying composition. Their physical and mechanical properties were tested in order to assess the suitability of formed boards for structural purposes.

Materials and Methods

The species used in this study was *Dendrocalamusstrictus,* which is one of the most common species of Bamboo and easily available in India. This bamboo species were collected from Forest Research Institute Campus Dehradun. Bamboo processed first in a chipper and then in condux mill. The particles were then sieved through 60 mesh and 40 mesh to get fine and coarse uniform size particles. The particles separated in coarse and fine so that the coarse particle in centre and the fine particle in both the face to get smooth surface. The coarse and fine particles weighted on oven dry basis according to requirement. Before

the mixing of cement the particles were soaked in water for 48hrs. Portland cement was used as a sizing agent. Different proportion of cement/bamboo particle ratios 2.0:1.0, 2.5:1.0, and 3.0:1.0 were used to study physical and mechanical properties of cement bonded particle board. To prevent hydration of wood with cement 2% Sodium Silicate (Na_2SiO_3) and 2% Aluminium Sulphate ($Al_2(SO_4)_3$) were added to accelerate cement setting. 28kg/cm^2 pressure were used in cold press for 6 hours. After pressing curing is done for 6 hours in oven and maintain temperature 50^{0}C. The boards were removed and wrapped with cellophane and kept in room temperature for 7 days. For maintaining 12% moisture content the board was again kept on oven to reduce moisture content of the board.

The test specimens were cut on a circular saw. The edges were trimmed to avoid edge effect on the board during testing. The board was further cut into various test specimens for evaluation of physical and mechanical properties of board according to IS 14276[5].

Results and Discussion

The mean values obtain for physical and mechanical properties such as Density, Moisture content, Water absorption, Thickness Swelling, Tensile Strength, Modulus of Rupture (MOR), Modulus of Elasticity (MOE) and Screw Withdrawal of Cement Bonded Bamboo Particle Boards are tabulated on Table-1 and Table-3. Table-2 and Table-4 show the One-way ANOVAat significance level in of 0.05 for the data obtained for all the properties evaluated. The results of exact behaviour among each of specific cement particle ratios, Duncan's subset were formed using SPSS.

According to the result it is observed that the moisture content, water absorption (2Hrs and 24Hrs), and thickness swelling is gradually decreasing with increase in cement: bamboo particle ratios (Table-1). The result presented (Table-1) is adequately compared well with those reported in literatures[6-8]. The highest values were observed with the cement: bamboo particle 2.0:1.0 ratios and the lowest were seen with the cement: bamboo particle ratios of 3.0:1.0. It indicates that property of dimensional stability of all the ratios of cement bonded particle board depends on the proportional of cement and lignocellulosic material. The Analysis of Variance and Duncan's subset for physical properties of cement bonded bamboo particle board (Table-2) clearly indicates that water absorption and thickness swelling are significantly different for all studied cement to bamboo particle ratio.

Table-1
Physical Properties of Cement Bonded Bamboo Particle Boards

Cement : Particle Ratios	Moisture Content (%)	Water absorption in 2hr water soaking (%)	Water absorption in 24hrs water soaking (%)	Thickness Swelling in 2hr Water soaking (%)
2.0:1.0	12.45^a	13.79^a	25.83^a	4.2^a
2.5:1.0	11.59^b	13.24^b	24.38^b	3.1^b
3.0:1.0	10.61^c	12.38^c	22.86^c	2.2^c

$^{a, b, c}$ = Significant ($p < 0.05$)

Table-2
ANOVA for Physical Properties of Cement Bonded Bamboo Particle Boards

Source of Variation	Sum of Square	Df	Mean Square	F	Sig.
Moisture Content (%)	17.068	2	8.534	239.651	0.00
Errors	0.961	27	0.036		
Total	4020.797	30			
Water absorption in 2hr water soaking (%)	10.14	2	5.07	302.946	0.00
Errors	0.452	27	0.017		
Total	5190.905	30			
Water absorption in 24hrs water soaking (%)	43.996	2	21.998	195.521	0.00
Errors	3.038	27	0.113		
Total	17846.399	30			
Thickness Swelling in 2hr Water soaking (%)	20.067	2	10.033	13.478	0.00
Errors	20.1	27	0.744		
Total	341	30			

The mean value of mechanical properties such as density, tensile strength, MOR, MOE is gradually increasing with increase in cement: bamboo particle ratio (Table-3). It is observed that the densities of 3.0:1.0 cement: bamboo particle ratio, CBPB is 1.2gm/cm^3 highest and the density of 2.0:1.0 cement bamboo particle ratios, CBPB is 1.16gm/cm^3 lowest among all studied cement to particle ratio. Tensile strength varies from 0.28 N/mm^2 to 0.40N/mm^2. The MOE varies from 4024 N/mm^{2}to 2494 N/mm^2. Screw Withdrawal strength to face and edge varies from 1229 N to 1329 N and 771 N to 876 N respectively with increase in cement: bamboo particle ratios. The MOR varies from 9.68 N/mm^{2}to 5.97 N/mm^2. The Analysis of Variance and Duncan's subset (Table-4) clearly indicated that MOR, MOE, Tensile Strength and Screw Withdrawal are significantly different forall studied cement: particle ratios.

Table-3
Mechanical Properties of Cement Bonded Bamboo Particle Boards

Cement : Particle Ratios	Density (g/cm^3)	Tensile Strength (N/mm^2)	Modulus of Rupture (N/mm^2)	Modulus of Elasticity (N/mm^2)	Screw withdrawal Face (N)	Screw withdrawal Edge (N)
2.0:1.0	1.16^a	0.28^a	5.97^a	2494^a	1229^a	771^a
2.5:1.0	1.19^b	0.34^b	8.18^b	3637^b	1281^b	834^b
3.0:1.0	1.20^c	0.40^c	9.68^c	4024^c	1329^c	876^c

$^{a, b, c}$ = Significant ($p < 0.05$)

Table-4
ANOVA for Mechanical Properties of Cement Bonded Bamboo Particle Boards

Source of Variation	Sum of Square	Df	Mean Square	F	Sig.
Density (g/cm^3)	0.007	2	0.004	25.504	0.00
Errors	0.004	27	0.001		
Total	42.043	30			
Tensile Strength (N/mm^2)	0.07	2	0.035	114.899	0.00
Errors	0.008	27	0		
Total	3.546	30			
Modulus of Rupture (N/mm^2)	69.786	2	34.893	199.654	0.00
Errors	4.719	27	0.175		
Total	1968.036	30			
Modulus of Elasticity (N/mm^2)	1.270	2	6324327.7	235.08	0.00
Errors	726377.3	27	26902.863		
Total	3.5701	30			
Screw withdrawal Face (N)	50820.267	2	25410.133	156.043	0.00
Errors	4396.7	27	162.841		
Total	4.920	30			
Screw withdrawal Edge (N)	56000.467	2	28000.233	95.953	0.00
Errors	7878.9	27	291.811		
Total	2.06	30			

Conclusion

The results obtained from this study showed that use of bamboo (*Dendrocalamusstrictus*) as a promising raw material for board production. This study aimed to determine the physical and mechanical properties of Cement Bonded Bamboo Particle Board prepare at different cement: bamboo particle ratios. The physical properties of board are decreasing with increase cement: particle ratios. The mechanical properties of the board are increasing with increase in cement: bamboo particle ratios. The 3.0:1.0 cement/bambooparticle ratio performed best for cement bonded bamboo particle board production.

Acknowledgements

The authors place on record the help rendered by the manager and staff members of NCL Industries, Paonta Sahib for making the CBPB samples. The help in conducting the raw material preparation by the staff of Composite Wood Discipline, Forest Products Division, FRI is gratefully acknowledged.

References

1. Ministry of Environment and Forest Government of India (1988). National Forest Policy (NFP). Government of India, www.envfor.nic.in.

2. Lee A.W.C. (1984). Physical and mechanical properties of cement bonded southern pine excelsior board. *Forest Product Journal*, 34(4), 30-34.

3. Lee A.W.C. (1985). Bending and thermal insulation properties of cement bonded southern pine excelsior board. *Forest Product Journal*, 35(11/12), 57-58.

4. De Souza M.R., Geimer R.L. and Moslemi A.A. (1997). Degradation of conventional and Co_2 –Injected cement bonded particleboard by exposure to Fungi and Termites. *Journal of Tropical Forest Product*. 3(1), 63-69.

5. BIS 14276 (1995). Cement Bonded Particle Board Specification. Bureau of Indian Standards.

6. Geimer R.L., Souza M.R., Moslemi A.A. and Sumatupang N.H. (1993). Carbondioxide application for rapid production of cement-bonded particle board. Moslemi, A. A. (Ed) Inorganic Bonded Wood and Fibre Composite Materials. Forest Prod. Res. Soc. Madison, Wis, 3, 31-4132-34.

7. Badejo S.O. (1990). Sawmill Wood residues in Nigeria and their utilization. Invited paper, Proceeding of the National workshop on forestry management strategies of self-sufficiency in wood production, Forestry Research Institute of Nigeria, Ibadan, 12-15.

8. Ajayi B. (2000). Strength and dimensional stability of cement-bonded flake board produced from *Gmelinarborea* and *LeucecinaLeucocephala*. PhD Thesis, Department of Forestry and Wood technology, 11-40.