

PRELIMINARY INVESTIGATION OF THE SUITABILITY OF *Chasmanthera dependens* (Hosct) AND WASTE PAPER FOR PRODUCTION OF CEMENT-BONDED COMPOSITE

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Abstract:

The physical and mechanical properties of cement bonded board produced from Chasmanthera dependens and waste paper was investigated in this study. Boards were produced at 50:50, 60:40 and 70:30 levels of blending proportions of paper-fiber by weight, 800kg/mm³ and 1000kg/m³ levels of board density and a constant mixing ration of 4:2 of cement-paper and fiber respectively. The boards were cut into test samples and physical and mechanical tests were carried out. The effect of Blending Proportion and Board Density on Water Absorption (WA), Thickness Swelling (TS), Modulus of Rupture (MOR) and Modulus of Elasticity (MOE) were determined using British standard 373. The mean values for WA ranged from 6.45-14.60%, TS ranged from 0.17-3.71%, MOE ranged from 93.90-946.03Nmm² while MOR ranged from 0.30-2.02Nmm². The results showed that increase in board density and blending proportion led to decrease in TS and WA but also resulted in increase in MOE and MOR. The study suggests that Chasmanthera dependens and waste paper are suitable for the manufacture of cement board.

Key words: *Chasmanthera dependens*; waste paper; dimensional stability; blending proportion.

INTRODUCTION

The increasing growth in the cement-bonded composite industry has given rise to investigation into some non-timber fiber products and agricultural residues that may be suitable for the production of cement bonded composites. The tropical forest has continued to reduce as a result of exploitation, This is so because of the high demand for wood and wood products as well as inefficiency in wood waste generated during the conversion process of log to timber at sawmills (Ajayi 2001). The large quantity of the waste generated during the conversion process of log to timber have been utilized over the years for the production of wood composites; resin fibre board, particle board, flake board, strand board, wood-cement composites and wood plastic composites. Recently, there have been a lot of ongoing researches on manufacture of inorganic bonded composite which involve the use of agricultural residue as alternative source of raw material. One of such materials is *Chasmanthera dependens*. The production of cement - bonded composite from *Chasmanthera dependens* will improve environmentally - friendly building, reduce deforestation, reduce waste and enhance sustainability of economic tree species in the tropics.

Cement-bonded boards were engineered particle composite produced from wood or other lingocellulosic raw materials bonded with inorganic binder (such as cement), chemical additives and water and then pressed under regulated pressure. Usually, cement - bonded wood are produced from strands, particles or fibers, agricultural residues and other sources of fibers mixed together with cement and manufacture into panels, bricks, tiles and other products used in the construction industry (Adediji and Ajayi 2008). The shortage of resources in general is a fact which forces the utilization of recycled wood and non - wood products (Wei et al. 2003).

Cement bonded board has gained favor throughout the constructional building industry due to its extended application compare to plywood, resin - bonded particleboard and other allied products (Eusebio 2003). Extensive studies on the expansion of raw material base have been done thereby demonstrating the feasibility of producing cement bonded composites using local wood species, some agricultural wastes and even industrial residues (Warden et al. 2000; Eusebio 2003). Cement bonded boards are wood - based panels which are more dimensionally stable under varying relative humidity change. They are good

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construction materials which are of great importance to mankind and possess unique qualities over other panel products.

METHODOLOGY

The boards were produced at three levels of blending proportion of waste paper-fiber (50:50, 60:40 and 70:30) and two levels of board densities (800kg/m^3 and 1000kg/m^3) at a constant cement-fiber/paper ratio of 2:1 translating into 6 treatment combinations. Calcium chloride (CaCl_2) was used as additive at 3% by weight of cement and the size of the boards that were produced was 10mm (thickness) $\times$ 350mm (width) $\times$ 350mm (length).

The required quantities of *Chasmanthera dependens*, waste paper and cement were weighted for different cement/fiber-paper ratio, mixed thoroughly in a mixer until a homogenous mixture was formed. The mixture was evenly distributed into a mould of $350\text{mm} \times 350\text{mm} \times 10\text{mm}$ and the formed boards were pressed under a hydraulic press (2.3N/mm^2 pressure). After 24 hours of pressing, the boards were removed and sealed in polythene bags for 28 days. Thereafter, they were trimmed, cut into test specimens and the respective physical and mechanical tests were conducted on the samples. Results indicated a direct relationship between blending proportion, density and WA, TS, MOE and MOR respectively.

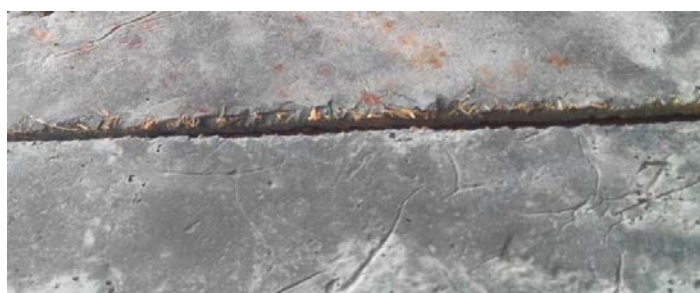


Fig. 1.
Cement boards produced.



Fig. 2.
Cement boards produced.

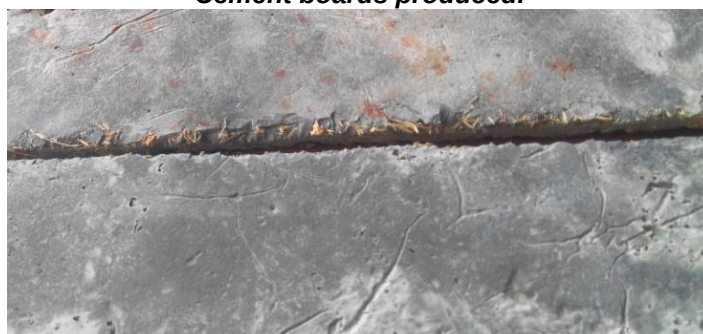


Fig. 3.
Cement boards produced.

RESULTS AND DISCUSSION

EFFECT OF DENSITY AND BLENDING PROPORTION ON THICKNESS SWELLING (TS) AND WATER ABSORPTION (WA) ON THE BOARDS.

The mean values for WA ranged from 6.45-14.60% and that of the TS from 0.17-3.71%. The rate of water absorption decreases with increase in the blending proportion and board density (Fig. 4) as also observed by Guntekin and Sahin (2009). The high rate of water absorption can be attributed to the strong

affinity of both paper and fiber for moisture and the differing rate of WA is accounted for by varying proportion of fiber in the boards. However, at an increasing density and blending proportion, cement coating of the matrix offers considerable resistance to moisture intake. This is because the cement has encrusted the fiber and prevented moisture intake which could eventually caused board spring back (Ajayi 2000, 2003). The rate of water absorption at density of 800kg/m^3 is higher than the 1000kg/m^3 of board produced (Fig. 5) due to less materials being compacted together leading to less fiber to fiber bond (Ajayi 2000). The rate of dimensional change of the boards decreases as the density and blending proportion increases. However, the most stable boards were produced at density level of 1000kg/m^3 and blending proportion 70:30 (paper-fiber). Table 1 shows the results of the analysis of variance for water Absorption and Thickness Swelling. The results indicated that the effect of density and blending proportion was significant for WA and TS of the boards.

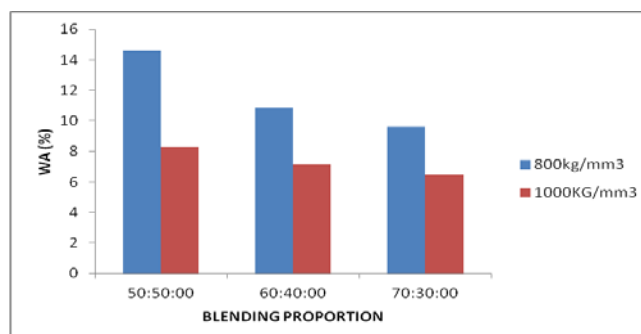


Fig. 4.
Effect of density and blending proportion on WA.

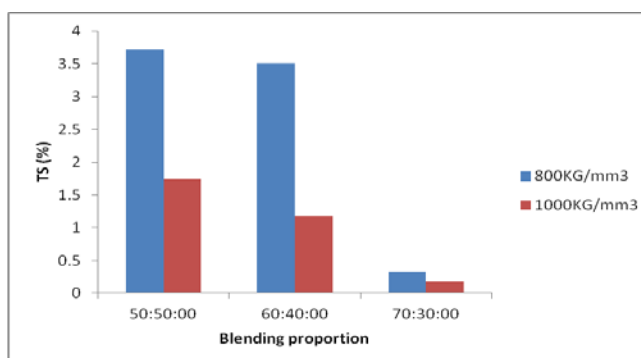


Fig. 5.
Effect of density and blending proportion on TS.

Table 1

Analysis of Variance for WA and TS						
	SV	SS	Df	MS	F	Sig.
WA	Density	145.420	1	145.420	3.892	.059
	Blending proportion	16.248	2	8.124	.217	.806
	Error	971.506	26	37.366		
	Total	3833.649	30			
TS	Density	8.172	2	4.086	4.086	.019
	Blending proportion	2.272	1	2.272	2.271	.134
	Error	116.002	116	1.000		
	Total	305.322	120			

Significant at $p \leq 0.05$

EFFECT OF DENSITY AND BLENDING PROPORTION ON MECHANICAL PROPERTIES

The mean values for MOE ranged from 93.90-946.03Nmm² while MOR ranged from 0.30-2.02Nmm². The values of MOE increases with increase in the density and blending proportion (Fig. 6). The high values of MOE recorded can be attributed to the facts that there is more cement in the board produced as the density increases (Badejo 1999, Ajayi 2000). Thus there is less void space in the board which could act as a point of failure during board testing and the total encasing of the fiber and paper increases the stiff nature of the board produced thereby increasing the amount of force that the board can accommodate before failure, This is supported with the findings of Moslemi and Pfister (1987) and Ajayi *et al.* (2015). The density of boards also had effect on the MOR, while the density increases, the MOR increases (Olonisakin *et al.* 2014). The values of MOR increases with increase in the blending (Fig. 7). The boards produced at 1000kg/m³ and 70:30 blending proportion had the strongest board in terms of the mechanical properties while the lower density boards and lower blending proportion had much less mechanical properties. The results of analysis of MOR show that the blending proportion had no significant effect on the modulus of rupture ($p \leq 0.05$) of board produced. The mechanical properties of any composite largely depends on the cellulose and hemicelluloses contents) has strong influences on the mechanical properties (Nemli *et al.* 2009; Pirayesh and Khazaeian 2012), since the fiber contain higher amount of cellulose the much higher mechanical properties are welcomed.

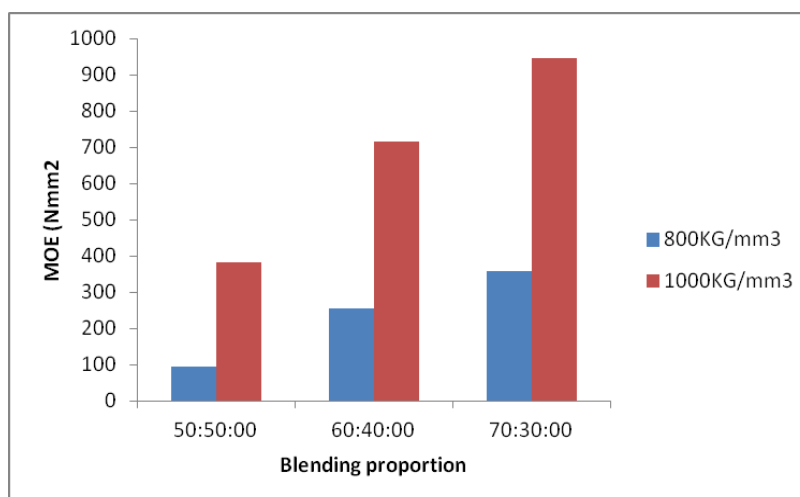


Fig. 6.
Effect of density and blending proportion on MOE.

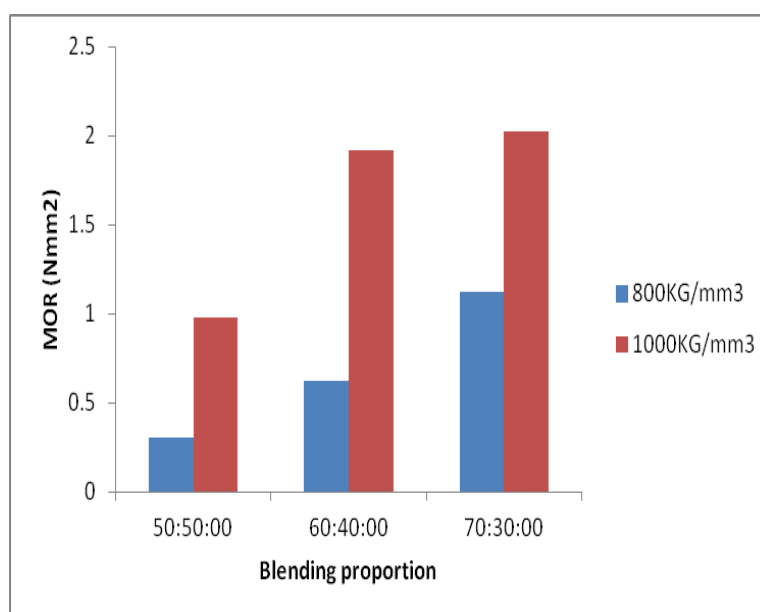


Fig. 7.
Effect of density and blending proportion on MOR.

Table 2

<i>Analysis of Variance for MOE and MOR</i>						
	SV	SS	df	MS	F	Sig.
MOR	Density	6.84	1	6.84	6.83	.015
	Blending proportion	4.51	2	2.26	2.25	.125
	Error	26.05	26	1.00		
	Total	77.85	30			
MOE	Density	1499224.66	1	1499224.66	10.96	0.003
	Blending proportion	862805.88	2	431402.94	3.15	0.059
	Error	3557044.05	26	136809.39		
	Total	12221643.77	30			

Significant at $p \leq 0.05$

Table 3

<i>DMRT for blending proportion</i>				
Blending proportion	TS	WA	MOE	MOR
50:50	0.96a	10.53a	651.30a	1.57a
60:40	1.58b	8.94a	238.51c	0.64a
70:30	1.13a	8.99a	485.24ab	1.27a

CONCLUSION

The production of cement bonded board was successfully investigated using the cement (Portland), fiber and waste paper. The density and blending proportion influenced the physical and mechanical properties of the board. Boards produced at higher density and higher blending proportion were more stable dimensionally and they also had better mechanical properties.

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