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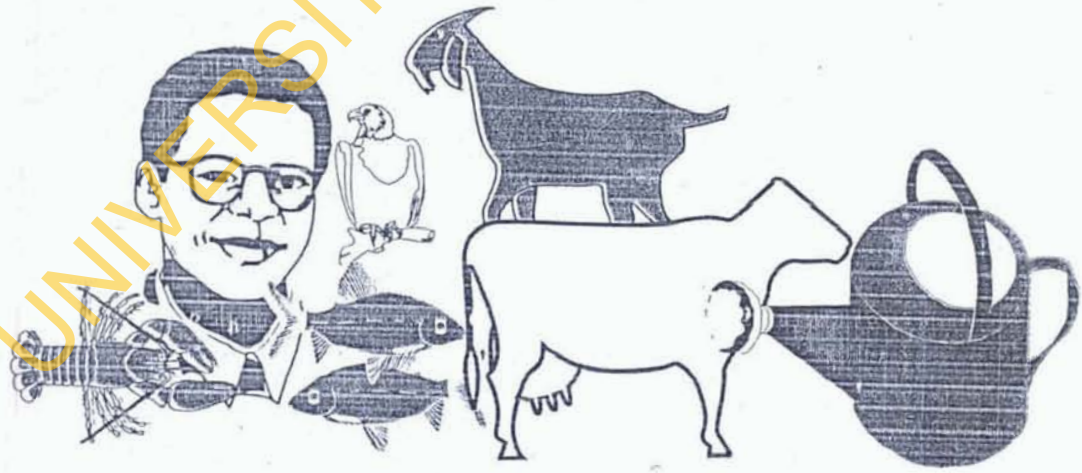

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FLEXURAL PROPERTIES OF WOOD CEMENT BOARD FABRICATED FROM CROPPING WASTES OF URBAN TREES IN A NIGERIAN UNIVERSITY.

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ABSTRACT

The study was undertaken to investigate the possibilities of producing cement bonded particle boards from wood wastes generated from 3 urban wood species in University of Ibadan with a view to evaluating the bending properties of cement boards so produced. The materials used for the boards' fabrication were wood wastes of Gmelina arborea, Delonix regia, Samena sena, Ordinary Portland Cement (OPC), water and calcium chloride.. The bending properties evaluated are the Modulus of rupture (MOR) and Modulus of Elasticity (MOE). Data collected were subjected to analysis of variance (ANOVA) at 0.05 probability level.

Results showed that the mean MOR values obtained from the fabricated boards ranged from 3.71N/mm^2 to 16.63N/mm^2 while the mean MOE recorded ranged from 1450.8N/mm^2 to 6654.9N/mm^2. The highest mean MOR was recorded from the boards produced with Gmelina arborea but Samena sena produced the strongest boards. Stronger, and stiffer boards were obtained at increasing levels cement/wood mixing ratio. The effect of wood species, mixing ratio levels and interaction were significantly different at 5% significance level.

Key words: wood cement board, cropping waste, urban tree, flexural properties

INTRODUCTION

The suitability of different lignocellulosic materials for the fabrication of wood-cement-panel (WCP) has been researched into and documented in literature and technical reports (Badejo 1983, 1985, 1989, Shittu 1990 and Oyagade 1992). The major findings are that complete compatibility of some wood species is hindered by inhibitory substances found especially in hardwoods species. These inhibitory substances, mainly extractives and polysaccharides, affect reactions between wood and cement resulting in boards of low quality. The nature of the extractives also has influence on the inhibitory effects. In solving these problems, inorganic chemical additives, or use of pretreatments such as aqueous extraction or hot water treatments have been employed. This has led to increased development in the accommodation of more species in the production of WCP. Wood is therefore an important raw material, for the production of wood cement boards. The quality of the end product depends mainly on the wood's physical and chemical characteristics. The wood materials is mostly obtained in form of round logs from thinning, logging, and wood processing residues such as slabs, edging, trimming from mills and furniture, factories, slab wastes and sawdust peelers. (Parker 1947 and Badejo 1983).

As a result of these, one major area which is being looked into in the production of wood cement panel is the utilization of wood waste for the production of these materials. Different research studies have been carried out on the utilization of wood waste to produce floor and wall tiles in the same density and size ranges like ceramic using cement bonding agent (Badejo 1986).

Apart from the properties of the wood materials used for the production of WCP, the quality of the panels so fabricated is determined majorly by the process variables employed during board production. These variables includes among others, board density, flake geometry, cement binder, wood and cement ratio, additive concentration, water cement ratio, pre-treatment temperature etc. The effect of these process variables have been studied and reported (Biston 1981., Simatupang 1981., Badejo, 1987, Fuwape and Oyagade, 1993., Omole and Badejo 1999., and Oyagade, 1988). In the present study, an effort has been made in this direction- to test for the suitability of selected wood wastes for board production using different process variables in order to assess the bending properties of the boards so produced. Properties assessed were the modulus of rupture (MOR) and modulus of elasticity (MOE).

MATERIALS AND METHOD

The materials used for this study were three wood species: *Gmelina arborea, Delonix regia, ,Samanea saman*. Ordinary Portland Cement (OPC), water and calcium chloride. The additive serves as a mineralizing agent to quicken the setting of the cement. The wood materials were collected as cropping wastes resulting from the management of some dangerous street trees in various part of University of Ibadan Campus.

The resulting particles from the wood species were dried in the open air for 2 weeks and subsequently treated with hot water at a temperature of about 85^0C. This pre-treatment was done in order to ensure the proper removal of the undesirable water soluble chemical substances (like phenolic compounds, oil extracts, starch etc.) which may likely inhibit the setting of the cement with wood. The pretreated particles were then air dried to a moisture content (M.C) of about 12% before further use. Calcium chloride ($CaCl_2$) was used as the additive. It served as a catalyst and mineralizing agent to improve the compatibility of the selected hardwood specie sawdusts with the cement binder by quickening the setting of the cement and retarding the effect of inhibitory substances.

Experimental Design and Board Production

The production variables for this study resulted in 3 x 3 factorial experiment in a complete randomized design. The combination gave 9 different treatment combinations and 10 replicates per treatment.

Blending and Mat Formation

The quantity of cement and wood particles were measured out according to the experimental variables and poured inside an aluminum bowl. Quantity of additive ($CaCl_2$) required was dissolved in the required quantity of water needed to produce a homogenous solution. The water solution was added and mixed together thoroughly until a well blended, lump-free finish was obtained. The furnish was hand formed into a uniform mat inside a wooden box of 350 mm x 350 mm that was placed on a caul plate made of iron. The mat formed was pre-pressed using wooden caul plates and the pre-pressed boards were loaded into the hydraulic press and pressure was applied at 1.23 Nmm^2 for 24 hours, before the demoulding.

After pressing, the mat still under compression was released and the boards removed from the mould and wrapped with polythene sheets and kept in the conditioning room for 28 days to enhance further curing of the cement. Thereafter, the board was stacked for 21 days

inside a controlled laboratory environment at a relative humidity of 65 ± 2%.The fabricated boards were then cut in test samples of 194 mm x 50 mm and loaded to a failure on a Hounsfield Tensometer testing machine. Both the Moduli of Rupture and Elasticity (MOR and MOE) of specimen were calculated as specified in the ASTM Standard No D-1037 of 1978. The MOR and MOE values for each replicate panel were taken as the mean for the test specimens per replicate.

RESULTS AND DISCUSSION

Modulus of elasticity

The values of modulus of elasticity (MOE) ranged from 1450.8N/mm^2 to 6654.9 N/mm^2. The highest MOR was obtained in cement-bonded particleboard produced with *Delonix regia* with a value of 6654.9N/mm^2. This was followed by boards produced with *Gmelina arborea* with a value of 4058.6N/mm^2 while the least value was recorded in the board from *Samanea sema* with MOE of 4020.3N/mm^2. The experimental samples of the particleboards produced with this municipal wood species sawdust are strong and compared favourably with the previous reports of Badejo (1999), Fuwape (1996), Oyagade and Fuwape (1998),

Table 1: Summary of Mean values of Modulus of elasticity (MOE) and modulus of rupture (MOR) of the particleboards produced from municipal trees

Wood species	Sawdust/cement ratio	MOE (N/mm^2)	MOR (N/mm^2)
Samanea	1:1	1956.2±489.0^{b}	3.82±1.28^{b}
	1:1.5	3314.0±926.8^{ab}	12.41±0.79^{b}
	1:2	4020.3±94.1^{b}	15.84±2.64^{b}
Delonix	1:1	1450.8±16.5^{b}	3.71±0.94^{b}
	1:1.5	2946.9±534.0^{b}	6.86±1.06^{b}
	1:2	6654.9±2091.3^{a}	15.84±2.64^{a}
Gmelina arborea	1:1	1969.7±823.6^{b}	4.58±1.12^{a}
	1:1.5	3182.9±728.7^{ab}	5.94±0.66^{a}
	1:2	4085.6±830.9^{a}	16.63±0.79^{a}

Mean values followed by the same letter in the same column are not significantly different at P< 0.05

The analysis of variance (ANOVA) conducted on MOE for the cement-bonded partic boards produced revealed that the effect of mixing ratio levels and interaction were significan different while the effects of the wood species were not statistically different at 5% significan level. This implies that of these factors only mixing ratio levels and interaction significan influenced the stiffness of the particleboard produced. The values recorded for modulus elasticity accordingly with different mixing ratios of the experimental boards revealed that boards followed the same trend with the findings of previous studies (Prestemon, 1976, Bade 1986, 1988, 1999). All the wood species used in the production of cement-bonded particleboa showed an increase in the modulus of elasticity with increase in the mixing ratio level of cement binder and sawdust used in the production.

Modulus of rupture

The least MOR value of 3.71N/mm^2 was recorded in boards produced from *Delonix regia* at a mixing ratio f 1:1 while the highest value of 16.63N/mm^2 was recorded from the board of *Gmelina arborea* at a mixing ratio 1:2 of wood and cement. *Samanea* produced the strongest board with 10.69 N/mm^2 as MOR, as against 9.05N/mm^2 and 8.80N/mm^2 for *Gmelina* and *Delonix* respectively. The experimental samples of the particleboards produced with this municipal wood species sawdust were stronger and stiffer.

Table 2: Mean Values of modulus of elasticity (MOE) and modulus of rupture (MOR) recorded for the fabricated boards

Process Variables		MOE		MOR		
Wood Species	Mixing Ratios	Mean	Std Deviation	Mean	Std. Deviation	N
S. sena	1:1	1956.20	489.00	3.82	1.28	3
	1:1.5	3314.03	926.76	12.41	0.79	3
	1:2	4020.27	94.11	15.84	2.64	3
	Mean	3096.83	1049.80	10.69	5.57	9
D. regia	1:1	1450.77	16.45	3.71	0.94	3
	1:1.5	2946.93	534.00	6.86	1.06	3
	1:2	6654.87	2091.25	15.84	2.64	3
	Mean	3684.19	2558.99	8.80	5.65	9
G. arborea	1:1	1969.70	823.59	4.58	1.12	3
	1:1.5	3182.97	728.65	5.94	0.66	3
	1:2	4058.60	830.90	16.63	0.79	3
	Mean	3070.42	1140.26	9.05	5.77	9

Statistical analysis revealed that the effect of wood species, mixing ratio levels and ?these factors (wood species, mixing ratio levels and interaction) significantly influenced the strength of the particleboard produced. The effect of these factors on the modulus of elasticity is dependent on wood/cement mixing ratios.

The mean values recorded for the mechanical properties as presented in Table 1shows that wood species do not really exhibit significant influence on the stiffness of the boards while there was significant relationship in the wood/cement ratios used for the production of experimental boards with mixing ratios 1:2 having the highest value of 4911.2N/mm^2. The values obtained for MOR revealed significant differences in both the wood species and the mixing ratios used for the production of particleboard. *Samanea,*with 10.69 N/mm^2 was the highest, followed by *Gmelina arborea* and *Delonix* of 9.05N/mm^2 and 8.80N/mm^2 respectively, *Gmelina arborea* and *Delonix* were not significantly different from each other, implying that the best wood species for the production of cement bonded particleboard is *Samanea*. The letter subscript used in the result of the follow-up tests conducted shows the difference between the wood species and mixing ratios. The sawdust/cement combination in the production of particleboard shows increases in the quality as the mixing ratios increases.

CONCLUSION AND RECOMMENDATIONS

Cement-bonded particleboards were successful produced from the three municipal wood species in mixing ratios of 1:1, 1:1.5 and 1:2. The strength properties of the boards produced revealed that particleboards with *Samanea* had the best strength properties than the other two wood species. The strength was not significantly different in flexural properties while boards from *Samanea* are the stiffest. The mixing ratios of the sawdust and the cement had significant effect on the properties. An increase in the sawdust/cement produced increases in the properties assessed. The best performance boards were recorded at 1: 2 that is wood to cement. Based on the result of this research report, *Samanea* sawdust would be a good substitute for *Gmelina arborea* in the production of cement-bonded particleboard.

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