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Effects of shelling ratios on the sorption and flexural properties of cement bonded paticleboard produced from mixed Nigerian hardwood species

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Abstract

Panel layer characteristics, otherwise referred to as shelling ratio, relate to the proportional ratio between the thickness of the fine surface layer and flake core layer materials in a 3-layered particleboard. The experiment was carried out in order to determine the most favourable core-surface thickness ratio at which board properties are maximized. To achieve this, experimental cement-bonded particleboards were made using three sawdust surface/flake core layer thickness ratios of 1 : 2, 1 : 1 and 2 : 1. Each of the ratio was considered at two board density levels of 1100 and 1200 kg/m^3 and two cement/wood mixing ratio of 2.25 : 1.0 and 2.75: 1.0. The experimental arrangement is a three-factor factorial experiment which manifested in 12 treatment combinations. The experimental boards produced were subjected to modulus of rupture (MOR), modulus oSf elasticity (MOE), water absorption (WA), thickness swelling (TS) and linear expansion (LE) tests. Data collected were subjected to statistical analysis using ANOVA and multiple linear regressions. The mean Moduli of Rupture and Elasticity (MOR and MOE) obtained ranged from 4.23 to 11.92 N/mm^2 and 1950 to 4140 N/mm^2 respectively. Water absorption (WA) and thickness swelling (TS) ranged from 24.75 to 10.58% (WA) and 0.41 to 4.01% (TS). It is noted that the mean values of MOR and MOE obtained at the sawdust surface layer/flake core layer thickness ratio of 1 : 2 were significantly superior at 5% level of probability to those obtained at the thickness ratio levels of 1 : 1 and 2:1. On the other hand however, the mean values of WA and TS obtained at the sawdust surface layer/ flake core layer thickness ratio of 2 : 1 were significantly superior at 5% level of probability to those obtained at thickness ratio levels of 1 : 2 and 1 : 1 of sawdust to flake contents of board. The highest strength and stiffness values obtained at the thickness ratio level of 1 : 2 of sawdust surface layer flake core layer notwithstanding, the thickness ratio level of 2 :1, which implies cement-bonded particleboard production at increased sawdust content and decreased flake content, was selected applied as a the optimum. This being so, in view of the fact that the overriding objective of the study was to produce 6 mm thick cement-bonded particleboards which could be resistant to moisture and adequate for house ceiling

Keywords: shelling ratios, sorption properties, flexural properties, wood cement board, thickness ratios

Introduction

Manufacturing difficulties experienced in the petro-chemical industries, high cost of organic binders and the need for conservation of crude petroleum all combined to encourage the search for alternative mineral binders such as Portland cement binders for the wood-based industries in many countries (Bison-Werke 1981, Hofstrand et al 1984). However, the drawback to wood-cement board production lies in the wood raw materials used as boards cannot easily be made from every wood, most especially the hardwood species. Board production is usually effected from wood species which have been tested and confirmed suitable. This has been the trend of industrial scale commercial production and laboratory research practices in different countries (Iddi et al 1992, Hawkes and Cox 1992).

The influences of some processs variables on the properties of particleboard have been of special interest to researcher in the field of wood composites manufacturing. These include cement/wood mixing ratio (an indicator of cement binder content in board), hot water pre-treatment methods and temperature, cement/water mixing ratio, chemical additive types and concentration levels, panel density, flake geometry and cement/water mixing ratio. Influence of mixing ratio at varying levels on properties of cement-bonded particleboard has been reported in the works of Namioka ct al. (1972), Prestemon (1976) Xia (1982) Badejo (1987), Oyagade (1990), Omole et al (1999) and Badejo et al (2010). The reported works of Dinwoodie (1978) and Lida et al (1983) made use of this production variable at a specified level. Using mixed wood particles of Picea jezoensis and Abies saccharlensis, Namioka et al (1972) worked on the influence of cement/wood mixing ratio within the range of 1.5 to 2.5 on properties of cement-bonded particleboards and reported that, static bending strength decreased with increase use of mixing ratio.

Another process variable of interest is particle geometry which relates to size dimensions of particles used for production of particleboards most especially with respect to length and thickness sizes. The effect of particle geometry on properties of cement-bonded particleboards from Larch wood samples were investigated by Yamagishi et al. (1981) while Badejo (1988) investigated the effect of board density at levels of 1050, 1125 and 1200 kg/m3 on properties of cement-bonded particleboards made from mixed particles of three Nigerian hardwood species. From his work, board fabrication at increasing density levels manifested in production of stronger, stiffer and more dimensionally stable cement-bonded particleboards. Fuwape and Oyagade (1993) reported on the influence of nominal board densities within the range of 800 to 1400 kg/m3 on bending strength and dimensional stability of cement-bonded particleboards made from Termlnalla superba species. Both the static bending strength and stiffness increased linearly with increase in board density. At constant level of cement/wood mixing ratio, water absorption and thickness swelling values of the boards also decreased with increase in board density (a measure of cement binder content in board). Thickness swelling of the boards however decreased with increase use of cement/wood mixing ratio. This indicates improved board dimensional stability with increase in panel's cement binder content.

However, very limited reports are available on the influences of panel layer characteristics on properties of cement-bonded particleboards from mixed tropical hardwood species. Where reported research studies exist, the findings obtained are sometimes conflicting and in most cases, such studies were based on use of temperate wood species. The experiment was therefore carried out in order to determine the most favourable core-surface thickness ratio at which board properties are optimized.

Materials and Method

Sawdust and wood residues were collected from six sawmills which were randomly selected among the mills which operate around Ibadan in Oyo state. The collected sawdust were then screened through 6mm mesh but retained in 2mm mesh. The screened sawdust were airdried for 4 weeks to allow for gradual degradation of starches and sugar present that could inhibit setting of cement binder. Slab pieces as collected from the sawmill were reduced to 1.2m length for proper handling and with the aid of tenoning machine, the slabs were prepared green into flakes of pre-determined length (37.5mm) and thichness (0.250mm) across the grain. Both the flakes and the sawdust were later pre-treated with hot water at a temperature of 800C, airdried to a moisture content of about 12% and bagged before board production.

Board Fabrication

The experimental cement-bonded particleboard was made using three sawdust surface/flake core layer thickness ratios of 1 : 2, 1 : 1 and 2 : 1. Each of the ratio was considered at two board density levels of 1100 and 1200 kg/m3 and two cement/wood mixing ratio of 2.25 : 1.0 and 2.75: 1.0. The experimental arrangement is a three-factor factorial experiment, a combination of which manifested in 12 treatment combinations. Chemical additives were incorporated at standard level of 3% based on the dry cement weight in board. Regardless of the board density and cement/wood mixing ratio levels, all the fabricated panels were of the following three types:

i. Panels with sawdust surface layer thickness of 2mm and flake core layer of 4mm (1 mm on each side of the core layer) to make up the panel's target thickness of 6mm (thickness ratio of 1: 2).

ii. Panels with sawdust surface layer thickness of 3mm and flake core layer of 3mm (1.5mm on each side of the core layer) to make up the panel's target thickness of 6mm (thickness ratio of 1:1)

iii. Panels with sawdust surface layer thickness of 4 mm and flake core layer of 2mm (2mm on each side of the core layer) to make up the panel's target thickness of 6mm (thickness ratio of 2 :1).

Replicate panels were produced in order to provide adequate test specimens for the experiment. The boards so produced were thereafter trimmed, cut into test specimen sizes and tested for flexural and sorption properties such as modulus of rupture (MOR), modulus of elasticity (MOE), water absorption (WA), and thickness swelling (TS) in accordance with the ASTM standard D1937 – 78. Data generated were subjected to ANOVA and multiple regression analyses.

Results and Discussion

Moduli of Rupture and Elasticity

The mean Moduli of Rupture and Elasticity (MOR and MOE) measured for each of the 12 treatment combinations used in this experiment are summarised in Table 1. MOR values ranged from 4.23 to 11.92 N/mm^2 while MOE values ranged from 1950 to 4140 N/mm^2. These range values, conform favourably to the range values of 3.28 to 10.46 N/mm^2 (MOR) and 2200 to 4010 N/mm^2 (MOE) reported by Badejo et al (2011). Furthermore, the mean MOR range values of 6.62 to 11.92 N/mm^2 obtained for some of the boards compared favourably to mean values of 11.3 N/mm^2, range values of 8.8 to 12.7 N/mm^2; 5.22 to 11.12 N/mm^2 and 6.21 to 9.65 N/mm^2 reported in literature by Dinwoodie (1978), Bison-Werke (1981), Badejo (1988) and (1989) respectively. In a similar vein, the MOE range values of 2410 to 4140 N/mm^2 obtained for 9 out of the 12 experimental treatment combinations compare favourably to the mean value of 2940 N/mm^2 and range values of 480 to 3400 N/mm^2 reported by Oyagade (1990). The factorial analysis of variance which tested the effects of panel layer characteristics as symbolised by sawdust surface layer/flake core layer thickness ratio and the other two production variables (cement/wood mixing ratio and board density) used along with it on strength (MOR) and stiffiiess (MOE) of the experimental panels is shown in Table 2. Thickness ratio, mixing ratio and board density were found significant at 1% level of probability on MOR and MOE. The two-way and three-way interactions between and among these three production variables were not significant. This implies that as the flake content of the boards increased, with consequent decrease in the sawdust content, stronger and stiffer cement-bonded particleboards are made from mixed particles of the hardwood species. This goes to show that panels made with proportional ratio of 1:1 of sawdust to flake input are weaker in static bending than those made with a proportional ratio of 1 : 2 of sawdust to flake but however stronger than those made with proportional ratio of 2 : 1 of sawdust to flake. The MOR and MOE of the experimental panels, at each of the thickness ratio levels of 1 : 2, 1 : 1 and 2:1, increased as the mixing ratio was raised from 2.25 : 1.0 to 2.75 : 1.0 of cement to wood in board. In a similar manner, stronger and stiffer panels were obtained as the density at which they were produced was raised from 1100 to 1200 kg/m^3. Considering all the 12 treatment combinations used in the study, the thickness ratio of 1 : 2, which implies 33.33 : 66.67% proportional ratio of sawdust/flake fibre input in board, the cement/wood mixing ratio of 2.75 : 1.0 and board density of 1200 kg/m^3 manifested in the production of strongest and stiffest cement-bonded particleboards with mean MOR values of 1.92 N/mm^2 and MOE of 4140 N/mm^2 respectively.

Follow-up tests conducted using Newman-Keuls test indicated, that the treatment mean MOR value of 8.65 N/mm^2 obtained at the thickness ratio of 1:2 of sawdust to flake in board was significantly higher at 5% level than at any of the other two levels. Similarly, the treatment mean MOR value of 7.45 N/mm^2 obtained at the thickness ratio of 1:1 of sawdust to flake proportion in board was significantly higher at 5% level than the mean value of 6.68 N/mm^2 obtained in panels made at the thickness ratio of 2 :1. The treatment mean MOR value of 9.76 N/mm^2 obtained at the higher cement/wood mixing ratio of 2.75 :1.0 was significantly higher at 5% level than the mean value of 5.42 N/mm^2 obtained at the lower mixing ratio level of 2.25 :1.0. Also, the treatment mean MOR value of 8.35 N/mm^2 obtained at the higher board density level of 1200 kg/m^3 was significantly higher at 5% level than the mean value of 6.84 N/mm^2 obtained at the lower density 1100 kg/m^3. Also for MOE, the treatment mean MOE value of 3290 N/mm^2 at the thickness ratio level of 1 : 2 was significantly different at 5% level from the mean value of 2570 N/mm^2 obtained at the thickness ratio level of 2 : 1 as well as the mean value of 2900 N/mm^2 obtained at the thickness ratio level of 1:1. Cement-bonded particleboards made from sawdust flake proportional ratio of 1:1were also significantly superior in static bending stiffness when compared to those made at the ratio of 2 : 1 of sawdust to flake. Furthermore, the mean MOE value of 3470 N/mm^2 obtained from the use of the higher mixing ratio of 2.75 :1.0 in this particular experiment was significantly different at 5% level from the mean value of 2360N/mm^2 obtained at the lower mixing ratio of 2.25 : 1.0. The noticeable increase in strength and stiffness of the experimental panels consequent upon an increase in the flake content of board during fabrication conforms with previous study reported by Prestemon (1976) and Badejo (1999).

The regression analysis performed on the test data, showing the correlation of the flexural properties with process variables is as presented Table 3. From the results obtained, sawdust surface layer/flake core layer thickness ratio, cement/wood mixing ratio and board density were highly correlated with MOR and MOE. Thickness ratio was negatively and linearly correlated with MOR and MOE while cement/wood mixing ratio was positively and linearly correlated with MOR and MOE. Board density was also positively correlated with MOR and MOE and these correlations were linear.

Table 1: Average values of MOR, MOE, WA and TS of cement-bonded particleboards produced at different levels of sawdust surface/flake core thickness ratios.

Treatment combinations			MOR (N/mm^2)	MOE (N/mm^2)	WA (%)	TS (%)
Sawdust /Flake thicknenesss ratio	Mixing ratio	Board density (kg/m^3)				
1.2	2.25:1.0	1100	5.73	2510	40.58	4.01
1:2	2.25 : 1.0	1200	6.62	2820	38.22	1.80
1:1	2.25 : 1.0	1100	4.68	2290	36.40	1.62
1:1	2.25:1.0	1200	5.15	2410	32.88	1.15
2:1	2.25 : 1.0	1100	4.23	1950	32.40	1.11
2:1	2.25 : 1.0	1200	5.31	2200	29.12	0.68
1:2	2.75 : 1.0	1100	10.32	3690	34.49	3.41
1:2	2.75 : 1.0	1200	11.92	4140	32.49	1.53
1:1	2.75:1.0	1100	8.43	3360	30.94	1.38
1:1	2.75 : 1.0	1200	10.73	3540	27.95	0.94
2:1	2.75 : 1.0	1100	7.62	2870	27.54	0.81
2:1	2.75 : 1.0	1200	9.56	3240	24.75	0.41

Table 2: Factorial analysis of Variance to test the effects of panel layer characteristics on cement-bonded Particleboards made from mixed particles of the Nigerian hardwoods.

Sources of variations	Df	Mean square values (MS)			
		MOR	MOE	WA	TS
Thickness Ratio (TR)	2	15.73**	2.11**	2.24**	16.075**
Mixing Ratio (MR)	1	226.20**	14.79**	3.28**	11.233**
Board Density (BD)	1	27.54**	0.94*	0.40*	1.222**
TRxMR	2	1.29	0.07	0.07	3.84**
TRxBD	2	0.30	0.06	0.20	0.043
MRxBD	1	2.24	0.03	0.19	0.057
TR x MR x BD	2	0.03	0.002	0.28	0.028
Error	36	0.84	0.22	0.097	0.012

* *Significant factors at 5% level of probability. Df. degree of freedom*
** *Significant factors at 1% level of probability.*

Table 3: Regression analysis to show the correlation of board properties with this process variables

Sources of variation	Degrees of freedom	Mean Square values (MS)			
		MOR	MOE	WA	TS
Regression	3	23.515*0.	1.6×10^6**	75.572**	3.2093*
Residual	8	265*	1.6×10^6*	1.177	0.4131*

* *Significant factors at 5% level of probability. Df. degree of freedom*
** *Significant factors at 1% level of probability.*

The multiple regression equations which relate MOR and MOE to the 3 production variables used in this particular experiment, with their corresponding correlation coefficient, R^2 values are as given in Table 5.For the two cases of MOR and MOE, the multiple regressions performed were highly significant at 1% level of probability. The coefficient of determination, R^2 value given by the stepwise regression analysis equations which relate each of the production variables alone as well as the two-way interaction between them on MOR and MOE are presented in Table 4. With correlation coefficient, R values of 0.302 and 0.444, thickness ratio was weakly correlated with MOR and MOE. Based on the low coefficient of determination, R^2 values of 0.098 and 0.197 obtained from the simple regression equations which relate it to MOR and MOE respectively, only 9.8% and 19.7% of the total variations of these dependent variables were explained by thickness ratio. These low R^2 values obtained for the thickness ratio suggest that there are other sources of vital variable inputs that need to be explored.

The mixing ratio as reported by Badejo et al (2011) was strongly correlated with MOR and MOE (correlation coefficient, R values of 0.882 and 0.855). The coefficient of determination values of 0.778 (MOR) and 0.731 (MOE) obtained implies that as much as 77.8% and 73.1% of the total variations of these dependent variables were explained by mixing ratio. Similar to the thickness ratio, board density, as investigated in this experiment, was weakly correlated with MOR and MOE as very low correlation coefficient, R values of 0.308 and 0.214 were obtained. The R^2 values of 0.095 and 0.046 were given by the regression equations which relate MOR and MOE respectively with this independent variable. These low values imply that only 9.5% and 4.6% of the total variations of MOR and MOE respectively were explained by board density. Also, the combined pair of thickness ratio and board density only explained 19.3% and 24.4% of the total variations of MOR and MOE respectively. However, the combined pair of thickness ratio and mixing ratio gave R^2 values of 0.876 and 0.928 on MOR and MOE respectively; while mixing ratio and board density combined gave R^2 values of 0.873 and 0.777. These high values mean in effect that combinations of thickness ratio and mixing ratio; as well as mixing ratio and board density are good predictors of MOR and MOE for this particular experiment.

Table 4: Step-wise regression analysis equation R* values relating Process variables and their interactions to the properties of the boards.

Factors of Production	Coefficient of determination (R^2)			
	MOR	MOE	WA	TS
Thickness Ratio (TR)	0.098	0.197	0.510	0.502
Mixing Ratio (MR)	0.778	0.731	0.349	0.023
Board Density (BD)	0.095	0.046	0.101	0.219
TR and MR	0.876	0.928	0.859	0.525
TR and BD	0.193	0.244	0.611	0.721
MR and BD	0.873	0.777	0.450	0.242
TR and MR and BD	0.971	0.974	0.960	0.744

Table 5: Multiple regression equations which relate MOR and MOE to the three production variables

Independent variables	Dependent variables	Equations	R values
TR, BD & MR	MOR	$Y_1 = -30.1 - 123X_1 + 8.68X_2 + 0.0152X_3$	0.985
	MOE	$Y_2 = -5312 - 462X_1 + 2220X_2 + 2.80X_3$	0.987

Y_1 and Y_2 = MOR and MOE respectively; X_1, X_2 and X_3 = independent (process) variables of TR, MR and BD

Water absorption and thickness swelling

Listed in Table 1, are the mean percent water absorption (WA) and thickness swelling (TS) of the experimental cement-bonded particleboards. For the 12 treatment combinations, the values ranged from 24.75 to 40.58% (WA) and 0.41 to 4.01% (TS). These range values, as obtained in this experiment, compare favourably to values recorded in the works of Fuwape and Oyagade (1993); Fuwape (1992); Bison-erke (1981); and Dinwoodie (1978).The factorial analysis of variance which tested the effects of sawdust surface layer/flake core layer thickness ratio, cement/wood mixing ratio and board density on WA and TS of the experimental cement-bonded particleboards is presented in Table 2. As shown, thickness ratio and mixing ratio were found significant at 1% level of probability on the two dependent variables measured in the experiment. However, board density was found significant at 5% level for WA but at 1% level on TS. Furthermore, the interaction between thickness ratio and mixing ratio was found significant at 1% level on TS. This means that the ability of the experimental panels to take up moisture under the prolonged soak in water for 144 hours decreased appreciably with increase in the sawdust content and consequent decrease the flake content of board. This implies production of more dimensionally stable cement-bonded particleboards from mixed particles of the Nigerian hardwoods. In effect therefore, ability of the panels to take up moisture and swell, following soaking, decreased as sawdust surface layer/flake core layer thickness ratio increased from 1 : 2 through 1 : 1 to 2 : 1. This observation is exactly the reverse case to what was obtained on the influence of this production variable on MOR and MOE of the experimental panels where increase in sawdust content with consequent decrease in flake content manifested in the production of weak panels which gave low MOR and MOE values when tested. The higher cement/wood mixing ratio of 2.75:1.0 and panel density of 1200 kg/m^3 produced cement- bonded particleboards which were more dimensionally stable under prolonged soak in water than those made at the lower levels of 2.25 : 1.0 and 1100 kg/m^3 respectively.

Application of Newman-Keuls follow-up tests to reveal the significant differences between the treatment means of the three production variables at the levels in which they were used showed that, the treatment mean WA value of 28.45% obtained at the sawdust surface layer/flake core layer thickness ratio of 2 : 1 is significantly lower at 5% level than the treatment mean values of 36.45% and 32.04% obtained at the thickness ratio levels of 1 : 2 and 1 : 1 respectively. Similarly, the mean value obtained at the ratio level of 1:1 was significantly lower at 5% than that obtained at the ratio level 1:2. The regression analysis carried out on the WA and TS test in order to show the correlation of these dependent variables with thickness ratio, mixing ratio and board density is presented in Table 3. Thickness ratio was negatively correlated with WA and TS and these relations were linear. Similarly, both mixing ratio and panel density were negatively correlated with WA and TS and the correlations were linear. The multiple regression equations which relate WA and TS to the three function variables applied in this experiment, with their corresponding correlation coefficient, R values, are presented in Table 6.

Table 6: Multiple regression equations which relate WA and TS to the three production variables

Independent variables	Depedent variables	Equations	R values
TR, BD & MR	WA	$Y_1 = 96.9 - 5.08X_1 - 10.5X_2 - 0.0282X_3$	0.980
	TS	$Y_2 = 15.7 - 1.18X_1 - 0.630X_2 - 0.00972X_3$	0.863

Y_1 and Y_2 = WA and TS respectively; X_1, X_2 and X_3 = independent (process) variables of TR, MR and BD

The multiple regressions performed were highly significant at 1% level of probability. The simple regression equation which relate thickness ratio with WA and TS gave correlation coefficient, R values of 0.714 and 0.709 respectively. So, thickness ratio fairly correlated with WA and TS. The coefficient of determination, R2 values of 0.510 and 0.502 obtained from the simple regression equations which related it to WA and TS respectively implies that 51.0% and 50.2% of the total variations of these dependent variables were explained by thickness ratio. Cement/wood mixing ratio and board density were weakly correlated with WA and TS based on computed correlation coefficient, R values of 0.590 (WA) and 0.152 (TS); as well as 0.318 (WA) and 0.468 (TS) respectively. As shown in Table 4, very low coefficient of determination, R2 were given. The mixing ratio accounted for only 34.9% and just 2.3% of the total variations of WA and TS respectively; while board density accounted for only 10.1% and 1.9% of the total variations of these two moisture response properties. The combined pair of mixing ratio and board density could also not serve to predict adequate variations in WA and TS as the regression equations which relate them to these dependent variables accounted of 45.0% and 24.2% of total variations of WA and TS respectively. On the other hand, the combined pair of thickness ratio and mixing ratio accounted for 85.9% and 52.5% of total variations of WA and TS respectively; while the combined pair of thickness ratio and board density accounted for 61.1% and 72.1% of total variations of WA and TS respectively. Invariably therefore, the combined pairs of thickness ratio and mixing ratio as well as thickness ratio and board density can serve to predict adequate variations in WA and TS as carried it in the experiment.

It is observed from the findings of the study that the negative effect which increased incorporation of sawdust and consequent decrease in flake content had on the strength and stiffness of test boards changed to a positive effect with respect to their moisture response properties of WA and TS. One reason which can be advanced for this noticeable phenomenon has to do with homogeneity of sawdust as a wood raw material. As the proportional ratio or content of sawdust in board increases, the degree of conformability between the wood particles is increased thereby manifesting in improved inter-particle contacts. The degree of porosity inherent in the test boards following pressing is therefore much reduced. The ability of such less porous boards to resist moisture uptake and excessive swelling under prolonged soak in cold water for 144 hours will be expected to be high. For this reason therefore, the decreasing WA and TS values obtained in the test panels made with increasing proportion of sawdust and decreased proportion of flake may be expected. At constant cement/wood mixing ratio, improved dimensional stability of cement-bonded particleboards with increased proportion of sawdust and consequent decreased proportion of flakes has been established (Prestemon 1976 Badejo 1999).

Furthermore, it is noted that the mean values of MOR and MOE obtained at the sawdust surface layer/flake core layer thickness ratio of 1 : 2 were significantly superior at 5% level of probability to those obtained at the thickness ratio levels of 1 : 1 and 2:1. On the other hand however, the mean values of WA and TS obtained at the sawdust surface layer/flake core layer thickness ratio of 2 : 1 were significantly superior at 5% level of probability to those obtained at thickness ratio levels of 1 : 2 and 1 : 1 of sawdust to flake contents of board. The highest strength and stiffness values obtained at the thickness ratio level of 1 : 2 of sawdust surface layer flake core layer notwithstanding, the thickness ratio level of 2 :1, which implies cement-bonded particleboard production at increased sawdust content and decreased flake content, was selected as a the optimum. This being so, in view of the fact that the overriding objective of the study was to produce 6mm thick cement-bonded particleboards which could be adequate for house ceiling following testing. For such use objective, the moisture response properties of the boards are relatively more important; and moreso, the mean MOR (strength) values of 6.68 N/mm2 obtained at this selected level of 2 : 1 compared well with published data on cement-bonded particleboard production from mixed wood raw materials (Prestemon 1976, Badejo 1989 and Badejo 1999).

Conclusions

Increased proportion of flakes and consequent decreased proportion of sawdust in board manifested in the production of stronger and stiffer cement-bonded particleboards. On the other hand, increased proportion of sawdust and consequent decreased proportion of flakes in board manifested in the production of more dimensionally stable cement-bonded particleboards. Flake thickness and sawdust-cement surface layer/flake-cement core layer thickness ratio were weak predictors of MOR and MOE but good predictors of WA and TS. Board density was more closely related to WA and TS than it was to MOR and MOE; while cement/wood mixing ratio was more closely related to MOR and MOE than it was to WA and TS.

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