PHYSICAL AND MECHANIC PROPERTIES OF PAPER CEMENT CEILING BOARD BONDED WITH PORTLAND AND PLASTER OF PARIS CEMENT

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ABSTRACT

The physical and mechanical properties of paper cement bonded ceiling board made from cement binder proportion (CBP) of Portland cement and P.O.P cement at 100% Portland cement (PC), 100% P.O.P, 50% PC: 50%P.O.P and 75% PC: 25% P.O.P. at mixing ratios (MR) 1:2 and 1:3 of paper to cement were investigated. The effect of Cement-Binder Proportion(CPB) and Mixing ratio on the density, water absorption (WA), thickness swell (TS), modulus of rupture (MOR) and the modulus of elasticity (MOE) were evaluated. The study showed that increase in the CBP of Portland cement and MR led to decrease in TS and WA at 24, 48 and 72 hours soaking test. In the case of the POP cement, its increase in the CBP led increase in TS and WA in 24, 48 and 72 hours. Boards produced with 100% POP cement binder at 1:2and 1:3 paper cement ratio failed the soaking test within and after 24 hours soaking. However the POP cement bonded board has a better surface finish. Boards made from CBP with higher proportions of Portland cement have higher strength values than those with high proportion of POP cement. The MR and CBP had a significant effect on the Density, TS, WA, MOR and MOE .This study affirmed the suitability of wastepaper recycling and effective ways of managing large quantity of paper waste generated in the packaging paper industry.

KEYWORDS: Kraft-paper, Portland cement, POP cement, mixing ratio, Density.

INTRODUCTION

The need to find an alternative material to abestos have led to carrying out study on the suitability of wastes such as polythene bags, paper, agricultural wastes, which are common sight in Nigeria. The amount of solid waste per capita generated in developing countries has risen to about 20 tons per year, it is observed that 45-50percent of original wood (timber) taken for mechanical processing ended in waste (Obam 2012). Saw-dust is a major component of the waste. It was estimated that the average office worker generates about 5 kg of wastepaper per month. Every ton of paper that is recycled saves about 1.4 cu m (about 50 cu ft) of landfill space. One ton of recycled paper saves 17 pulpwood trees (Fuwape, *et al*. 2007). These wastes can be turned into value added raw material readily available for cement bonded ceiling boards industries, thereby reducing the cost of building materials and creating jobs for the unemployed.

Cement-bonded wastepaper-made board is a promising product that uses paper wastes as its main raw material. Manufacturing process does not require sophisticated equipment and hence the board can be made in small rural-based plants using simple technology. It can also be manufactured in industrial areas using the by-products of paper mill industries. Manufactured boards find a ready market for housing and construction, but they need to meet certain standards Furthermore, since there are many deteriorating agents in Nigeria, boards need to possess resistance to decay and attack by termite

(Ogunrinde 2012).Agricultural residues such as bagasse, banana stem, maize stalk, yam stem, coffee chaff and cotton stalk among others have also been experimented for the manufacture of different panel products (Ajayi 2002).

Production of ceiling boards from waste Kraftpaper with cement (Portland cement and P.O.P) as binders provides another option to wood waste like sawdust, wood chips etc. Wastepaper generated from sources such as the millbrokes, newsprints, offices, schools, markets often constitutes and pose nuisance to the environment with a view to putting these waste into much more efficient use by providing an alternative to conventional building materials such as asbestos that is costly and also poses health risks.

The objectives of this study was to produce ceiling boards from mixture of Kraft paper using Portland cement and POP cement, as binders determine the density of the boards produced, evaluate the physical and mechanical properties of the board produced.

MATERIALS AND METHODS

Materials Procurement and Preparation

Waste Kraft paper was collected from Walex Paper Industry in Akure, Nigeria (a Paper Carton Producer) and the binders used (Portland and P.O.P cements) were bought from a cement seller also in Akure, Ondo State, Nigeria from fresh consignment and also the addictives (calcium chloride) was bought from Chelab Agrochemical store in Akure, Ondo State, Nigeria.

Waste Kraft paper was soaked for a period of two weeks and afterwards milled to the finest mixture using a milling machine. Adequate quantity of water was added to the paper during milling to ensure a smooth milling process and to achieve the finest texture possible after which the milled paper were put in a perforated bag to allow for proper drainage of water from the milled paper. The quantity of paper and cement used was calculated and measured at fixed weight ratio of paper and varied ratios of cement: 1:2 and 1:3 paper/cement ratio and blending proportion of 100% Portland cement, 100% POP cement, 50: 50 Portland cement/POP and 75:25 Portland cement and POP respectively. Each unit of formulation was mixed thoroughly in the milling machine with a little quantity of water, chemical additive (calcium Chloride), 3% of the amount of cement used in the mixture was calculated and added to the mixture in the milling machine after been mixed with the required amount of water.

An already prepared wooden mould that has been greased with lubricant to allow for easy removal of the board after pressing was already put in place , the size of the mould was 600 x 600 x 8mm.The mixture were then discharged from the machine and poured on the ground to allow for drainage and loaded on to the already prepared mould after which it was covered with a white thick nylon and then covered with the mould's cover made of plywood and marine grade board and then placed under the hydraulic press to form the required thickness of 8mm and the board was kept under the press for at least 6hours after which they were removed from the press, demoulded, and were stacked to allow for them to cure for a period of 28days and then after which the necessary tests were carried out.

After 28days of curing, the board edges were trimmed with circular saw to avoid edge effect and were cut into the required sizes of 3 samples per board (140 x 140 x 8mm and of 190 x 50 x 8mm) for the physical and mechanical tests respectively which includes the density, water absorption, thickness swelling and the mechanical tests which includes modulus of elasticity and modulus of rupture according to British Standard Method (1979) for particle board test. Statistical Package for Social Sciences (SPSS) was used to analyze the data obtained from the study. Analysis of variance was carried out to evaluate the relative importance of various source of variation on density, thickness swelling, modulus of rupture and modulus of elasticity. The effect of mixing ratio and blending proportion on these variables were examined. The follow- up test (Duncan Multiple Range Test) was conducted at 0. 05 levels to know the difference between the means and to choose the best treatment combination from the factors considered

RESULTS AND DISCUSSION

PHYSICAL TEST

The density for the board produced across the cement-binder proportion and paper to cement mixing ratios are presented in table 1. The result shows that density increases as the proportion of Portland cement increases in the cement-binder proportion. The density of the board is substantially influenced by the proportion of cement binder used, showing that density is directly proportional to the mixing ratio which agrees to previous research work done by Owoyemi and Ogunrinde (2013). On the other hand, an increase in the proportion of POP cement used led to a decrease in board density. It can also be seen in Table 1 that as the board density increased, the rate of water absorption and thickness swell decreased and this is in consonance with the previous research carried out by Ajayi (2005), Akinbodunse (2011) and Ogunrinde (2012) that board density has significant effect on its dimensional stability. Increase in density generally resulted in higher Modulus of elasticity and Modulus of Rupture which totally agrees with previous research carried out by Guntekin and Sahin (2009) Pulido (1993) and Fernandez (1996).Which stated the higher the density of the board, the greater its mechanical properties.

The mean values obtained for Water absorption (WA) ranged between 52.44±1.84% to 116.65±4.53% for cement-binder proportion 100% PC to 75%PC:25%POP for mixing ratio 1:2 and 38.67±3.95% to 76.56±5.48% of cement-binder proportion 100PC to 75%PC:25%POP for Mixing ratio 1:3. Thus the values obtained range from 38.67±3.95% to 116.65±4.53%, The response of the boards to water intake showed that increase in cement/kraftpaper (Mixing Ratio 1:3) and increase in the proportion of Portland cement in the mixing ratio of the board produced caused decrease in W.A level, However, boards that were produced with 100% POP as the binder failed the water absorption test less than 24 hours, thus no values were recorded for them. which totally agrees with the previous work by Ogunrinde (2012) and Sotannde *et al* (2012). Water absorption decreases with increase in the density which totally agrees with the previous work by Guntekin and Sahin (2009). The result of the analysis of variance, showed that Water Absorption is significantly affected by Mixing Ratio, cement binder proportion and also the interaction between Mixing Ratio and cement-binder Proportion has significant effect on water absorption.

The mean values obtained for Thickness swelling (TS) ranged between 1.33±0.09% to 25.29±0.42% of cement-binder proportion 100% PC to 75%PC:25%POP for mixing ratio 1:2 and 0.44±0.00% to 35.04±1.54% thus the values obtained range from o.44±0.00% to 35.04±1.54%. The board's thickness swelling decrease with increase in mixing ratio and increased percentage of Portland cement in the cement-binder proportion. . The higher dimensionally stable board was obtained from the highest mixing ratio of 1:3 and the cement-binder proportion of 100% PC. Analysis of variance shows that thickness swell is significantly affected by Mixing Ratio, cement binder proportion and also the interaction between Mixing Ratio and cement-binder Proportion (MR*BP) has significant effect on thickness swelling.

Table 1: Descriptive Analysis showing the mean values for Density, Thickness Swelling and Water Absorption

CEMENT-BINDER PROPORTION	WATER ABSORPTION (WA%)			THICKNESS SWELL(%)			MEAN DENSITY (kgm^{-3})
	WA(%) 24HRS	WA(%) 48HRS	WA(%) 72HRS	TS(%) 24HRS	TS(%) 48HRS	TS(%) 72HRS	
100%PC 1:2	60.26±0.47	60.57±0.61	63.13±2.01	1.03±0.09	1.69±0.14	2.26±0.12	1063.29
100% POP 1:2	*	*	*	25.29±0.42	*	*	745.97
50%PC 50%POP 1:2	115.46±4.49	115.87±4.51	116.65±4.53	3.22±0.09	3.73±0.13	3.92±0.13	852.30
75%PC 25%POP 1:2	52.44±1.84	53.21±2.16	53.77±2.10	0.47±0.04	1.46±0.22	1.54±0.21	1248.41
100%PC 1:3	38.67±3.95	39.30±4.02	39.92±4.03	0.44±0	0.73±0	1.97±0	1626.55
100%POP 1:3	*	*	*	30.04±1.54	*	*	936.31
50%PC 50%POP 1:3	75.19±5.89	75.75±5.68	76.56±5.48	1.63±0.16	1.94±0.03	2.28±0.29	1088.33
75%PC 25%POP 1:3	59.10±1.29	60.46±1.44	60.46±1.44	0.76±0.08	1.19±0.11	2.95±0.42	1307.339

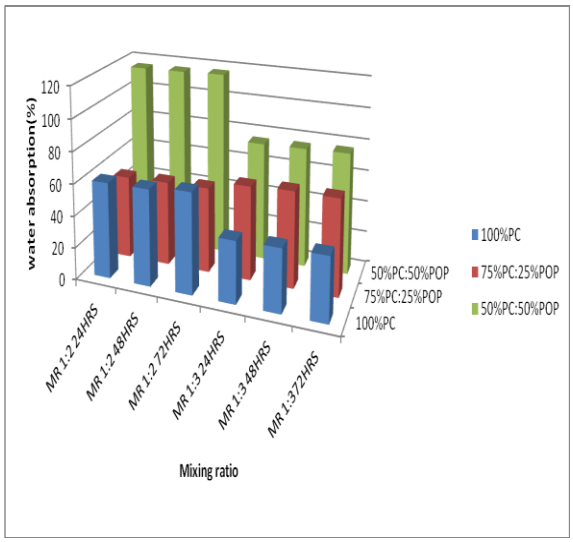

Fig 1: Effect of Mixing Ratio and Cement Binder Proportion on Water Absorption in 24, 48 and 72 hours

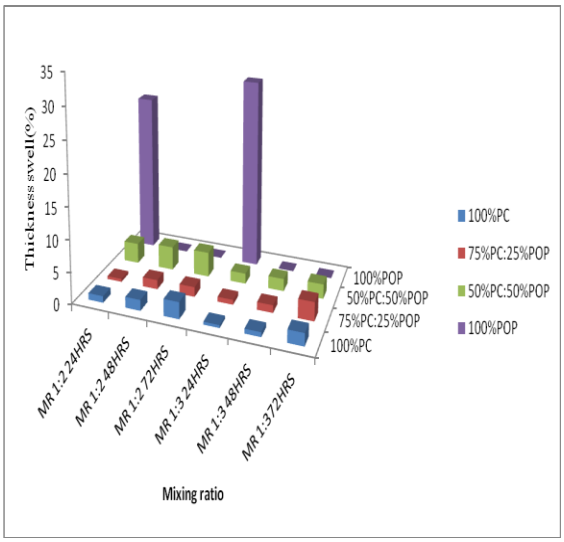

Fig 2: Effect of Mixing Ratio and Cement Binder Proportion on Thickness swelling in 24, 48and 72 hours

MECHANICAL TEST

The mean values of Modulus of Elasticity (MOE) of the Paper Cement Bonded Board produced as shown in table 2 means that the strength properties of the board produced is greatly affected by the Mixing Ratio and Cement Binder Proportion. The mean values is between 298.80±62.45 N/mm^2 and 3885.68±65.45 N/mm^2 for all the 1:2 and 1:3 paper-cement mixing ratios and the corresponding cement binder proportions respectively which increased when there is an increase in the proportion of Portland cement in the cement binder proportion. This showed that boards with high mechanical properties can be produced when Portland cement are used as the sole binder or when Portland cement is of the higher proportion when been used with other binders which conforms with the previous done by Omole and Adetogun (2010). The result of Analysis of Variance (ANOVA) reveals that MOE is significantly affected by mixing ratio, cement binder proportion and the interaction between mixing ratio and the cement binding proportion, and this result corresponds to the findings of Ogunrinde (2012) and Fuwape *et al* (2007).

The Modulus of Rupture (MOE) mean values shown in Table 2 ranged from 0.71±0.02 to 9.66±0.05N/mm^2 from mixing ratio 1:2 to mixing ratio 1:3 respectively. This showed that boards with high mechanical properties can be produced when Portland cement are used as the sole binder or when it is of the higher proportion when been used with other binders. However, the study showed that mixing ratio, cement binder proportion and interaction between cement binder proportion and mixing ratio had a significant effect on the boards produced. Figure 4 showed that the board with the highest mechanical property was produced at the higher level of the mixing ratio of (1:3) and cement binder proportion of 100% Portland cement, while the lowest board in strength was produced at the lower mixing ratio of 1:2 and blending proportion of 100% POP cement. Analysis of Variance (ANOVA) showed that MOR is significantly affected by mixing ratio, blending proportion and the interaction between mixing ratio and blending proportion. Modulus of Rupture values increased with mixing ratio and density, and decreased with increased thickness swelling and also increased with a decrease in water absorption.

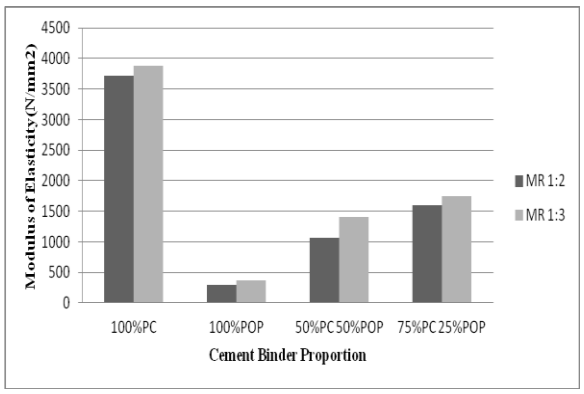

Fig 3: Effect of Mixing Ratio Cement Binder Proportion on Modulus of Elasticity

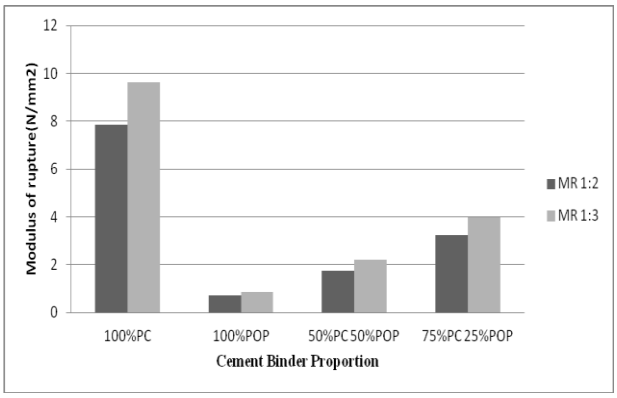

Fig 4: Effect of Mixing Ratio and Cement Binder Proportion on the Modulus of Rupture

Table 2: Descriptive Analysis of Modulus of Rupture and Modulus of Elasticity

CEMENT BINDER PROPORTION	MODULUS OF ELASTICITY (MOE) N/mm^2	MODULUS OF RUPTURE (MOR) N/mm^2
100% PC 1:2	3720.91±24.48	7.87±0.02
100% POP 1:2	298.80±62.45	0.71±0.02
50% PC 50% POP 1:2	1066.64±14.64	1.75±0.02
75% PC 25% POP 1:2	1596.28±12.43	3.25±0.02
100% PC 1:3	3885.68±62.44	9.66±0.05
100% POP 1:3	376.92±18.82	0.88±0.01
50% PC 50% POP 1:3	1408.61±38.97	2.21±0.01
75% PC 25% POP 1:3	1750.44±8.62	4.02±0.01

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CONCLUSION

Environmental nuisance and pollution caused by the volume of paper waste generated in nigeria has been a major concern. paper recycling has offered a way out of the menace by ensuring that even waste paper can still be put to a value added product such as paper cement bonded ceiling boards. the boards produced with 100% portland cement as the binder has better physical and mechanical properties than boards that were produced with 100% pop cement as the binder while 100% pop failed the physical test in less than 24hours and also recorded very low values from the mechanical test conducted on all the samples.

It can be concluded that pure cement remains by far a better binding agent in the production of paper made boards, however, pop cement bonded boards have better surface finish. the use of paper-made pop cement-bonded ceiling boards should be restricted to interior applications because of its good finishing property, they should however not be used in a damp area or places exposed to water.

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