Original Research Article

PHYSICO–MECHANICAL PROPERTIES OF CEMENT BONDED PARTICLES BOARD MADE FROM DATE PALM FIBRES (*Phoenix dactylifera*) AND OBECHE SAWDUST (*Triplochyton schleroxylon*)

Abstract

The study carried out to determine the possibilities of using Date palm fibres and Obeche sawdust in the production of cement bonded particles board and their physical and mechanical properties were tested. The materials used for the study were Date palm fibres, Obeche sawdust and chemical catalyst. The Date palm straws were pounded in to fiber and mixed with Obeche sawdust and chemical additives ($CaCl_2$) in a wood- cement ratio of 1:2.0, 1:2.5, 1:3.0 and 1:3.5. Chemical catalyst was diluted in water at 3%. Water was also added to mixture and mixed thoroughly and then put on mat sized 250mm × 250mm × 250mm square and pre- pressed. It was then carried to the hydraulic jack and pressed under pressure for 24h and then released and recovered with a black nylon for seven days conditioning. Then, boards were subjected to physical and mechanical evaluation. The physical property was determined by using water absorption and swelling thickness. The initial measurement for weight, length and thickness were taken and then boards were immersed in a container full of water for 24 h and then measured for seven days. On the other hand, the mechanical strength was determined by employing a concrete crushing machine, where the boards were subjected to crushing pressure to the breaking point and data were observed and recorded. The result of the study showed that good quality cement bonded particleboards can be produced with date palm fibres and Obeche sawdust. The study further showed that the boards produced with wood – cement ratios 1:3.0 *and* 1:3.5 *possessed high quality.*

INTRODUCTION

Cement bonded particleboards were composite product made from wood particles (shavings, chips and sawdust) as reported by Ajayi (2004). The main use of particleboards is in structural application. Cement bonded particleboards consist of certain qualities over panel product such as plywood and fibres board (Badejo 1986). The common quality of cement bonded particleboards were durability in terms of sound absorption and the resistance to degradation / fungal attack and their perceived performance during natural disaster and tropical storms (Malmey and Remirezcoretti, 1998). These qualities of cement bonded particleboards qualifies it to be a versatile construction material in that it can be used for roofing, ceiling, flooring partitioning, cladding and shutting (Badejo, 1986).

Cement bonded particleboards are made from the mixture of Portland cement, chemicals and water, conventionally a glass of water is added to the mixture to accelerate the setting of Portland cement (Apar, 2000). After blending a three layer mat is formed by two wing formers and one mechanical former. The mats are piled and pressed together with steel plates in batches (Hadnagy, 1993). Pretreatment is very essential in cement bonded particle board production in that it enhances the ability of bonding wood with cement (Moslemi and Lim 1984). The objectives of the paper is to assess the physico-mechanical properties of cement bonded particle board made from Date palm fibres (*Phoenix dactylifera*) and Obeche sawdust (*Triplochyton schleroxylon)*

Materials and Method

The materials used for the study were Date palm fibres, Obeche sawdust, Ashaka Portland cement and chemical additive ($CaCl_2$). Date palm stem were pounded into small particle size (30 mm) and mixed with Obeche sawdust as well as Askaka Portland cement. After that the mixture was poured on a mat and compressed under a hydraulic jack pressure for 24 h. After releasing the boards they were put into a black nylon for conditioning for 28-29 days under room temperature (Ajayi, 2000). And data were subjected to statistical analysis using complete randomized design.

Pre-treatment method

The wood material was poured into a big pot and heated up to 85 °C in order to remove wood extracts that can hinder binding and setting of cement (Ajayi, 2002). The Date palm fibres and sawdust were boiled at 100 °C for 2 h after which it was brought down and allowed to stay for about 30 min hot water, drained and exposed to sun-drying for seven days (Ajayi, 2002).

Board formations

The boards were formed based on specific dimensions of 250 mm × 250 mm × 250 mm. The materials (mixture of Date palm fibres and Obeche sawdust) were blended with Portland cement at a mixing ratio of 1:2.0, 1:2.5, 1:3.0 and 1:3.5. After blending, the mixture was put and spread onto a mat in the boards frame for acquiring required shape, then pre-pressed and moved to the compression site where the boards were subjected to pressure under a hydraulic jack for 24 h.

Water absorption and thickness swelling

The boards were selected randomly from various mixing ratios and immersed in water for three consecutive days, and the measurement involved length, thickness as well as weight were taken after 24 h. The boards were replicated three times and the measurements were taken before and after immersion in water. Formula used to determining percentage water absorption and swelling thickness of the boards is as follows:

Thickness swelling = $((T_2 - T_1) / T_1) \times 100$ % - - - - - - (1)

Water absorption = $((W_2 - W_1 / W_1) \times 100$ % - - - - - (2)

Where;

T_1= initial thickness;

T_2= final thickness;

W_1=initial weight of the board;

W_2= final weight of the board.

Modulus of Rupture (MOR)

The modulus of rupture in this study was obtained through the equation below and the boards used were replicated three times. Meanwhile, the load applied on the boards to rupture was determined from the compression by the crushing machine used.

MOR = $3(PL) / 2(bd^2)$ Nmm^{-2} - - - - - - - (3)

Where;

P = Load or maximum load (N);

L= length of the board (mm);

B= Width of the board (mm);

D= thickness of the board (mm).

Compressive strength

Mechanical property was determined by subjecting the board samples to compressed by means of crushing machine and exerted force or pressure by compressing the boards to the point that it would no longer be compressed and reading was recorded as the compressive strength of the board for the three replicates (Table 2)

Modulus of elasticity (MOE)

The MOE of the boards where determined by using equation below;

MOE = stress/ strain. - - - - - - - - - (4)

Results and Discussion

Physical properties

Water absorption and swelling thickness of the boards in relation to various mixing ratio were presented in Table 1. The results showed that variations in wood – cement mixing ratio had a significant effect (p <0.05) on the water absorption of the boards. The rate of water absorption decreased with increase in cement content of the boards. Boards produced with 1:2.0. Wood – Cement mixture had the highest average water absorption of 10.29% which was not significantly different from 10.22% obtained when 1:2.5ratio was used, but differed significantly from 6.14 % and 5.86% obtained from the mixing ratios of 1:3.0 and 1:3.5, respectively which signified that low cement ratio might lead to higher water absorption and thereby resulting to poor strength and density. This is in line with the observation of many researchers (Badejo, 1987, Oyagade, 1995) and the use of chemical additives played a vital role in inhibiting the higher percentage water absorption of the boards.

Thickness swelling

This also varied significantly with wood – cement ratio. The boards produced with 1:2.0 wood-cement ratios had the highest thickness swelling by average value of 17.95%. The trend was the same when 1:2.5 wood- cement ratio was used, while the least average thickness swelling of 4.01% was obtained when wood- cement ratios increased to 1:3.5 .This is in line with Oyagde (2000); Halingan (1970) reported that there are relationship between modulus of rupture and the board thickness. Therefore, cement bonded particle board with low cement ratio should be avoided because it possessed high thickness swelling and can easily be broken down meanwhile wood-cement ratio of 1:3.5 was recorded with the least thickness swelling which implies that cement bonded particle board thickness swelling has strong relationship with cement proportion in the mixture, therefore, more cement should be used in making cement bonded particleboards.

Table 1: Physical Properties of the boards in relation to mixing ratio

Wood-cement ratio in weight	Water absorption (%)	Thickness swelling (%)
1:2.0	10.29 + 0.29[a]	17.00 + 2.22[a]
1:2.5	10.22 + 0.25[a]	9.02 + 2.38[b]
1:3.0	6.14 + 027[b]	7.36 + 0.53[c]
1:3.5	5.86 + 0.24[b]	4.01 + 0.54[c]

Values with the same alphabet within same the column are not significantly different at 95% confidence level

Mechanical properties

The results of mechanical properties of the boards in relation to the mixing ratio were presented in Table 2. The study reveals that compressive strength, modulus of rupture (MOR) and Modulus of elasticity (MOE) have significant influence on cement bonded particleboards.

a) Modulus of rupture (MOR)

The result of the modulus of rupture showed that variation in wood-cement mixing ratio had significant influence on the MOR of the boards ($p<0.05$). The boards produced with wood cement ratio of 1:2.0 had the highest MOR of 0.27 Nmm^{-2} and followed by 0.21 Nmm^{-2} obtained when 1:2.5 was used and the lower values ranged from 0.15 to 0.18 Nmm^{-2} were obtained from mixing ratio of 1:3.0 and 1:3.5 respectively. Several authors reported an inverse relationship between the wood-cement ratio and MOR (Moslemi and Lim 1984, Papadopoulos, 2006). However, MOR decreases with an increase in wood-cement ratio because higher quantity of wood in the board enhanced flexural properties of the board that is consistent with this study.

b) Modulus of elasticity (MOE)

The results of modulus of elasticity showed that variation in wood produced with wood-cement ratio of 1:2.0 had the highest MOE of 4.18 Psi (Table 2). Meanwhile, average MOE ranged from

2.18 to 2.50 Psi obtained in 1:3.0 and 1:2.5 wood -cement ratio respectively. However, the least MOE of 1.99 Psi was obtained when 1:3.5 wood-cement ratios was used. This signifies that increased in cement content contributes positively to the strength of the boards, thereby resulting enhancing the modulus of elasticity in the boards (Latorraca and Iwakiri, 2000). However, density of the boards made from wheat straw coconut chips and bamboo chips significantly influenced the particleboards strength properties (Zheng *el al.*, 2007).

Compressive strength

The results presented in Table 2 showed that variation in wood – cement ratio had significant effect ($p<0.05$) on the compressive strength of the boards. The compressive strength decreased with increase in cement content of the boards. Higher compression value was obtained in 1:2.0 ratio by 6.05N while; lower value of 3.45N was found in 1:3.5 wood-cement ratios respectively. The results of this study is consistent with what was reported by Benyar and Mindness (1990), that wood fibers are generally not used to improve the compression of wood-cement bonded composite through a small improvement in strength may sometimes resulted from their use.

Table 2 Mechanical Properties of Cement bonded Particle Boards

Mixing Ratio	MOR (Nmm^{-2})	MOE (Psi)	Compressive Strength (N)
1:2.0	$0.27+0.21^{a}$	$4.18+0.02^{a}$	$6.05+2.52^{a}$
1:2.5	$0.21+0.01^{b}$	$2.50+0.06^{b}$	$5.04+4.00^{b}$
1:3.0	$0.18+0.002^{c}$	$2.18+0.04^{c}$	$4.17+2.65^{c}$
1:3.5	$0.15+0.002^{c}$	$1.99+1.76^{d}$	$3.45+4.51^{d}$

Values with the same alphabet within same column are not significantly different at 95% confidence level

CONCLUSION

Date palm fibres and Obeche sawdust can be used in manufacturing cement bonded particleboards at higher cement ratio for quality products as the revealed in this study wood-cement ratio of 1:3.0 and 1: 3.5 produced strong boards that might be used for ceilings or floor purposes in that physical and mechanical properties of the boards were tested and confirmed that outlined mixing ratio can be used for such application. Meanwhile, as the cement ratio increase, the mechanical properties of the boards also increased but lowered the physical properties of the boards.

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