Original Research Article

PHYSICO–MECHANICAL PROPERTIES OF CEMENT BONDED PARTICLE BOARD MADE FROM DATE PALM FIBRE (*Phoenix dactylifera*) AND OBECHE SAWDUST (*Triplochytonschleroxylon*)

Abstract

The study carried out to determine the possibilities of using Date palm fibre and Obeche saw dust in the production of cement bonded particles board the boards were tested based on their physical and mechanical strength. The materials used for the study were Date palm fibre, Obeche saw dust and chemical additives. The Date palm straws were pounded in to fiber and mixed with Obeche saw dust 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 additive was added based on the proportion of cement used. Water was also added and mixed thoroughly and then put on mat sized 250mm by 250mm square and pre- pressed. It was then carried to the hydraulic jack and pressed under pressure for 24 hours and then released and put in a black nylon for seven days conditioning. After that, the boards were subjected to physical and mechanical properties test, the physical property was determined by using water absorption and swelling thickness. The initial measurement for weight, length and thickness were taken and then immersed in a container full of water for 24 hours and then measured for seven days. On the other hand, the mechanical strength was determined through the use of 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 particle board can be produced with date palm core 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 that can be used for floor tiles and as well ceiling boards.*

Comment [AB1]: PARTICLES
Comment [AB2]: FIBRES
Comment [AB3]: space
Comment [AB4]: fibres
Comment [AB5]: sawdust
Comment [AB6]: and physical and mechanical properties of cement bonded particle boards
Comment [AB7]: fibres
Comment [AB8]: sawdust
Comment [AB9]: $CaCl_2$
Comment [AB10]: wood-cement ratio (in mass)
Comment [AB11]: Chemical catalyst were diluted in water at content (3% to..%)
Comment [AB12]: Pressure?...MPa?
Comment [AB13]: h
Comment [AB14]: recovered with a
Comment [AB15]: Then, boards were
Comment [AB16]: evaluation
Comment [AB17]: boards were
Comment [AB18]: h
Comment [AB19]: by employing a device (model?)
Comment [AB20]: particleboards
Comment [AB21]: allowing their applications for
Comment [AB22]: in this case, it´s necessary to perform a flexure test

INTRODUCTION

Cement bonded particle board is a composite product made from wood particles (shavings, chips and sawdust) Ajayi, 2004. The main use of particle board is in structural application. Cement bonded particle board consist of certain qualities over panel product such as plywood, fibre board etc (Badejo 1986). The common quality of cement bonded particle board is durability in terms of sound absorption andresistance to degradation / fungal attack and their perceived performance during natural disaster and tropical storms (Remirezcoretti *et al.,* 1998). These qualities of cement bonded particleboard 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 particle boards 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 (Alpar, 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, Short and Lee 1989)

The objectives of the paper is to assess the physico- mechanical properties of cement bonded particle board made from Date palm fiber(Phoenix dactylifera) and Obeche saw dust (*Triplochyton schleroxylon)*

Materials and Method

Comment [AB23]: paticleboards were
Comment [AB24]: , as reported by Ajayy (2004).
Comment [AB25]: And theirs principal applications is
Comment [AB26]: particleboards
Comment [AB27]:
Comment [AB28]:
Comment [AB29]: etc.
Comment [AB30]: particleboards were their
Comment [AB31]: and the resistance
Comment [AB32]: Absent in the references
Comment [AB33]: particleboards
Comment [AB34]:
Comment [AB35]: particleboards
Comment [AB36]: volum?
Comment [AB37]: Apar or Alpar?
Comment [AB38]: Absent
Comment [AB39]: .
Comment [AB40]: .
Comment [AB41]: Absent
Comment [AB42]: physico-mechanical
Comment [AB43]: italic
Comment [AB44]: sawdust
Comment [AB45]: .
Comment [AB46]: .

The materials used for the study were Date palm fiber, Obeche sawdust, Portland cement and chemical additive ($Cacl_2$). Date palm stem were pounded into small particle size and mixed with Obeche sawdust as well as Portland cement. After that the mixture was poured on a mat and compressed under a hydraulic jack pressure for 24 hours. After releasing the boards they were put into a black nylon for conditioning for 28-29 days under room temperature (Ajayi, 2000).statistical design used was 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 fiber and sawdust were boiled at 100°c for 2hours after which it was brought down and allowed to stay for about 30 minutes in hot water, drained and exposed to sun drying for seven days (Ajayi, 2002).

(a) Board formations

The boards were formed based on specific dimensions of 250mm by 20mm.The materials (mixture of Date palm fiber and Obeche saw dust) was 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 the purpose of acquiring required shape, then pre-pressed and moved to the compression site where the boards were subjected to pressure under a hydraulic jack for twenty four hours.

(b) 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 hours. The boards were replicated three times and the measurements were taken before

Comment [AB47]: Type????
Comment [AB48]: (smaller than..2.40 mm, for example)
Comment [AB49]: h
Comment [AB50]: Statistical…independent variable?
Comment [AB51]: 85 °C
Comment [AB52]: ,
Comment [AB53]: fibers
Comment [AB54]: 100 °C
Comment [AB55]: h
Comment [AB56]: min
Comment [AB57]: 250 mm x 250 mm x 20 mm
Comment [AB58]: fibers
Comment [AB59]: sawdust
Comment [AB60]: , in weight
Comment [AB61]: For acquiring
Comment [AB62]: 24 h
Comment [AB63]: h

and after immersion in water. Formula used to determining percentage water absorption and swelling thickness of the boards is as follows:

- Thickness swelling = **T_1-T_2/ T_1 x100**
- Water absorption = w_2-w_1/w_1x100
- Where;

T_1= initial thickness

T_2= final thickness

W_1=initial weight of the board

W_2= final weight of the board

(c) Modulus of rupture (MOR)

The Modulus of Rupture in this study was obtained through equation ~~by substituting the value obtained from various measurements of the boards such as load or force, length, breadth and thickness and the~~ boards used were replicated three times.

MOR = $3PL/2BD^2$

Where,

P= Load or maximum load

L= length of the board

B=breadth of the board

D= thickness of the board

The load was obtained from the compression strength for each of the three replicates of the boards produced in different mixing ratios.

(d) Compressive strength

Comment [AB64]: $((T_2-T_1)/ T_1)$ x100%

Comment [AB65]: $((w_2-w_1)/w_1)$x100%

Comment [AB66]: ;

Comment [AB67]: ;

Comment [AB68]: ;

Comment [AB69]: .

Comment [AB70]: Number?

Comment [AB71]: Information about device: model, speed,..

Comment [AB72]: Equation

Comment [AB73]: Unit? N? mm?

Comment [AB74]: ;

Comment [AB75]:

Comment [AB76]: ; Unit?

Comment [AB77]: ;

Comment [AB78]: ;

Comment [AB79]: width

Comment [AB80]: ;

Comment [AB81]: .

Comment [AB82]:

Comment [AB83]: maximum

The mechanical property was determined by subjecting the board samples to the 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)

b) Modulus of elasticity (MOE)

The MOE of the boards where determine by using equation of elasticity

MOE = stress/ strain. ~~As stated eelier, the study involved the determination of physical and mechanical properties of cement bonded particle boards where physical properties measurement involved length, weight and breath) and mechanical properties involved compressive strength, modulus of rupture and modulus of elasticity.~~

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 was observed to decrease 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 1:2.5 ratio 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 proportion 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 percentage water absorption of the boards (Izran *et al*.2008).

Comment [AB84]: They were the halves from flexure test? Or they were independent?

Comment [AB85]: Test device

Comment [AB86]: . Graph?

Comment [AB87]: How slope of the curve was measured?

Comment [AB88]: particleboards

Comment [AB89]: width

Comment [AB90]: Table

Comment [AB91]: decreased with

Comment [AB92]: %

Comment [AB93]: ,

Comment [AB94]: ratio

Comment [AB95]:)

Comment [AB96]: higher

Comment [AB97]: Absent

Comment [AB98]: ,

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 with an 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) that there are relationship between modus of rupture and the board thickness. Internal bond strength was also scrutinized by Halingan (1970) in relation to thickness swelling of the board. Therefore, cement bonded particle board with low cement proportion 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 cement particle board production.

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

Mixing ratio	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[b]
1;3.5	5.86+0.24[b]	4.01+0.54[b]

Mechanical properties

Comment [AB99]:

Comment [AB100]: modulus

Comment [AB101]: This isn´t the subject of this paper

Comment [AB102]: ratio

Comment [AB103]: What about economics?

Comment [AB104]: (cement:wood, ratio in weight)

Comment [AB105]: 1:2.0

Comment [AB106]: 1:2.5

Comment [AB107]: 1:3.0

Comment [AB108]: 1:3.5

Comment [AB109]: Average with the same letter….at 95% of statistical…

Comment [AB110]: What about standard deviation? Or Variation coefficient (%)?

Table 2 below showed the mechanical properties of the boards in relation to the mixing ratio in comparing compressive strength, modulus of rapture and Modulus of elasticity

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 M.O.R of the boards ($p<0.05$). The board produced with wood cement ratio of 1:2.0 had the highest value with an average value of 0.27Nmm^2 closely followed by 0.21Nmm^2 obtained when 1:2.5 was used and 1:3.0 and 1:3.5 had the least average value of 0.18 and 0.15Nmm^2. Several authors reported an inverse relationship between the wood-cement ratio and MOR (Moslemi and Pfister 1987, Papadopoulos *et al.*, 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 which is in line with this study.

b) Modulus of elasticity (M.O.E)

The analysis of variance for modulus of elasticity showed that variation in wood produced with wood-cement ratio of 1:2.0 had the highest value with an average value of 4.18Nmm^2. Low values were obtained when wood- cement ratio of 1:2.5 and 1:3.0 were used giving 2.50mm^2 and 2.18mm^{2}respectively. The least average MOE of 1.99Nmm^2 was obtained when 1:3.5 was used. This showed that increased in cement content contributes positively to the strength of the boards, thereby resulting in increased modulus of the boards (Latorraca and Iwakiri, 2000). However, density of the boards made from wheat straw coconut chips and bamboo chips significantly influenced the particle board strength properties (Zheng *el al*, 2007).

Compressive strength

Comment [AB111]: eliminate
Comment [AB112]: shows
Comment [AB113]: erase
Comment [AB114]: rupture (MOR)
Comment [AB115]:
Comment [AB116]: MOR
Comment [AB117]: boards
Comment [AB118]: 0.27 $N.mm^{-2}$
Comment [AB119]: Absent
Comment [AB120]: Verify
Comment [AB121]: that
Comment [AB122]: Where is ANOVA data?
Comment [AB123]: *et al.,*

The analysis of variance for compressive strength showed that variation in wood – cement mixing ratio had significant effect ($p<0.05$) on the compressive strength of the boards. The compressive strength in table 2 was observed to decrease with increase in cement content of the boards. The boards produced with 1:2.0 woods – cement mixture had the highest average compressive strength of 6.05Nmm^2, 1:2.5 had 5.0Nmm^2, 1:3.0 had 4.17Nmm^2 and 1:3.5 had 3.45Nmm^2 respectively. Bentur (1990) observed 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 the boards in Relation to mixing ratio

Comment [AB124]: Table

Comment [AB125]: decreased with

Comment [AB126]: These are the same information at the table

Comment [AB127]: and Mindness

Table 2 Mechanical Properties of Cement bonded Particle Board

MIXING RATIO	M .O.R	M.O.E	COMPRESSIVE STRENGTH
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[c]	2.50+0.06[b]	5.04+4.00[b]
1:3.0	0.18+0.002[b]	2.18+0.04[c]	4.17+2.65[c]
1:3.5	0.15+0.002[b]	1.99+1.76[d]	3.45+4.51[d]

Comment [AB128]: MOR

Comment [AB129]: Unit?

Comment [AB130]: MOE

Comment [AB131]: Unit?

Comment [AB132]: Unit?

Comment [AB133]: b

Comment [AB134]: c

Comment [AB135]: c

CONCLUSION

The finding from this study has shown that cement bonded particle boards can be produced with date palm fibre and Obeche saw dust. The physical and mechanical properties of the boards influenced the various mixing ratios. Increased in cement proportion of the board lowered the percentage water absorption and thickness swelling of the boards. However, modulus of rupture,

Comment [AB136]: The goal of this study was to demonstrate the feasibility of the cement bonded particleboards manufacturing by using Date……

Comment [AB137]: Inverse…Mixing ratios influenced..

Comment [AB138]: Physical-mechanical properties of the boards decreases for lower cement-to-particles content.

modulus of elasticity and compressive strength were also observed to increase as cement proportions increased in the board materials

References

Ajayi, B. (2002): Preliminary investigation of cement bonded particle board from maize stalk residues, Nigeria Journal of Forestry 33(1):33-37

Ajayi, B. (2004): Reaction of cement bonded composite from Gmelina arborea and Leucocaena leucocepha to water treatment:Nig.journal of forestry 34(2): 125-131

Apar, T. 2000: Accelerating methods for cement curing in production of cement-bonded particle boards. Ph.D. thesis, UWH, Sopron.(Hungarian)

Badejo, S. O.O, 1987. An investigation on the influence of cement binder content on properties of cement bounded particles boards from Tropical hard woods. Malaysian forester 50(1):107.120

Badejo S. O.O 1986. Dimensional Stability of cement bonded particle board from eight tropical hardwoods Grown in Nigeria. Nig. J. Forr. 16(1&2): 16-17

Bentur. A and Mindness, S. 1990. Fibre reinforced cement composites Else vier science publisher limited Essers, England 449pp

Halligan, A.F. (1970): A review of thickness swelling in particle boards.Wood sci.Tech. 4:301-312

Hadnagy, J. 1983: Production and utilization of particle boards. Muuskzaki Konyvkiado, Badapest, p.373. (Hungarian)

Latorraca J.F and Iwaki S (2000) Efeitos do tratamento das particulas de Eucalyptus dunnii (Maid), da varaicao da relacao Madeira-cimento e do uso de aditivos sobre as propriedades fisicas e mecanicas de chapas de Madeira-cimento. Cerne, 6(1):68-76

Malmey,T and Remirezcoretti(1998):.Modern particle board and dry process Fibre board manufacturing, miller Freeman Pub. Inc, SanFrancisco, C.A., U.S.A (2)
.

Moslemi, A.A (1987): the influence of cement/wood ratio and cement type on bonding strength and dimensional stability of wood –cement composite panels. *Wood and fiber science* 19(2):165-175

Oyagade A.O (1995). Influence of Portland cement Alkalinity on the Dimensional stability of cement-wood particle board. Nig. J. For. 24(1&2):21-25

Comment [AB139]: ,

Comment [AB140]: Nig. Journal of Forestry

Comment [AB141]: hardwoods

Comment [AB142]: Forester

Comment [AB143]: Or (1986)

Comment [AB144]: For.

Comment [AB145]: Sci.

Comment [AB146]:

Comment [AB147]: Iwakiri

Comment [AB148]: variação da relação

Comment [AB149]: alkalinity

Comment [AB150]: dimensional

Oyagade A.O (2000). Thickness Swelling components and water Absorption of cement bonded particle boards made from Gmelina wood, Bagasse and coconut Husk. Nig. J. For. 30(1):10-14

Papadopoulos, A.N (2006): Mechanical and physical properties of cement-bonded OSB. *Holz als Roh-and werstoff* 64:517-518

Zheng Y, Zhongli LP, Zhang RH, Jenkins BM, Blunk S (2007).Particle board quality characteristics of Saline Jose Tall Wheat grass and chemical treatment effect. Bioresource Tech. 98(6):1304-1310

Comment [AB151]: et al.?