Dimensional Properties of Cement-Bonded Wastepaper and Sawdust Composite Board

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ABSTRACT: *The thickness swelling and shrinkage of cement-bonded boards in response to cyclic exposure to water – soaking and oven-drying conditions was examined. The panels were made at four mixing ratios of 3.5:1, 3.0:1, 2.5:1 and 2.0:1 (weight to weight basis) and at three nominal density levels of 1300, 1200 and 1000kg/m³. The result indicated that there was an increase in the thickness swelling and shrinkage of boards subjected to cyclic water soak and over-dry for the first five cycles while a constant thickness swelling and shrinkage was maintained following further soaking and drying.*

Key Words: *Thickness Swelling, Shrinkage, Water Soaking, Density, Oven- Drying*

Introduction

Cement-bonded boards produce from wastepaper and sawdust has a high potential for serving as a constructional material for building low cost houses in the developing countries. Dinwoodie & Paxton (1989) noted that cement bonded-board has advantages over resin-bonded particleboard because of its higher dimensional stability, high resistance to insect and fungal attack and higher fire resistance.

The major problem with wood-cement bonded board is that it has high weight to strength ratio. The high weight of wood-cement is due to large proportion of cement used during the manufacturing process. At present, the commercially manufactured boards are produced in the range of 2.75-3.0 parts of cement to 1.0 parts of wood (Bison & Greeten, 1977).

In this study, an attempt was made to reduce the cement/wood ratio of the composite so as to lower the weight of the board and to reduce the cost of production since cement is more expensive than wood and wastepaper. One of the problems with particleboard utilization is dimensional instability; it swells when exposed to moisture from the environment and shrinks with loss of moisture. This behaviour which depends on the production variables of the board, determines its utilitarian value,

The objective of this study was to examine the thickness swelling and shrinkage behavior of cement bonded boards made from wastepaper and sawdust composite at different combination ratios with varying nominal densities.

Materials and Methods

Sawdust of Triplochitonscleroxylon (Obeche) was collected from two sawmills which were randomly selected among mills which operate in Akure, Ondo State. The sawdust was air seasoned for four weeks in order to enhance gradual degradation of starches and sugars present in the wood which could impede setting of the cement binder.

Wastepapers were collected from Omolayo standard Press Limited Ado-Ekiti, Ekiti State. Sawdust collected were soaked in hot water for a period of four hours in order to remove the extractive content in it. The wood waste was later sun-dried for a week. The sun-dried sawdust was sieved with 2mm sieve so as remove the fine particles of sawdust.

The particles were kept in the laboratory for a week to attain equilibrium moisture content with the laboratory environment. The waste papers were soaked in water for fifteen days. They were beaten and defibred in a grinding machine. Water was removed from these materials by keeping them in a local press for 24 hours and finally kept in the laboratory for a week in order to attain equilibrium moisture content with laboratory environment.

The process variables used for board production were:

1) Cement/wastepaper/sawdust ratio of 3.5.1,3.0:1,2.5:1 and 2.0:1.
2) Nominal board densities of 1000,1200 and 1300kg/m³

The cement used was type 1 Portland cement, calcium chloride (3% by weight of cement) was used as an accelerator to improve cement hydration.

The quantity of distilled water used was calculated using the formula developed by Simatupang (1979). The formula is given as water in
(litres) = 0.35c+ (0.30-MC)w
C=weight of cement(kg)
MC =Moisture content of wood (oven dry base)
W= weight of oven – dry wood (kg)

The quantity of wastepaper, sawdust, water and cement required to produce panels measuring 600mm (wide) by 600mm (long) by 8mm (thick) were weighed for different cement/wastepaper and sawdust ratios at predetermined densities. The required quantity of air-dry sawdust and wastepaper were dropped in a bowl and a solution of calcium chloride ($Cacl_2$) was sprayed uniformly on it while stirring. The predetermined quantity of cement was added and the slurry was thoroughly hand mixed (using hand glove) until a homogenous sawdust-wastepaper-water-cement mix was formed.

The composite slurry was a hand-felted into a mat of 600mm by 600mm and cold pressed to the required thickness of 8mm. The mat remained under press for 24 hours. After 24 hours of cold pressing, the panels were removed from the metal plates and wrapped in polythene bags for 48hours before they were trimmed and cut to the required sample sizes in accordance with the British Standard B.S. 5669: Part I of 1989. The test specimens were conditioned in a room and maintained at a relative humidity of 65% and temperature of 20°C for 28 days. After the 28 – day curing period, five samples from each treatment were tested for thickness swelling and shrinkage following cyclic exposure to oven drying and 24-hour water immersion.

The specimens were oven dried for 24 hours at 105°C and thickness taken at four points around the edges with dial guage. The samples were then soaked in a water bath with water for a period of 24 hours. The samples were removed after 24 hours and spread on non-absorbent surface for about ten minutes so as to remove excess water from the samples before the thickness was measured. The drying and soaking of these board specimens were repeated in cycles for seven times with the thickness taken following the same process for each cycle.

Results and Discussion

Cyclic water soak and oven-dry

The results of the percentage changes in thickness during the cyclic water-soak and oven-dry conditions are presented in table 1. The pattern of variations in cyclic water-soak and oven-dry conditions are illustrated as shown in (Figure 4.1-4.4). From the graphical illustrations (Figure 4.1 - 4.4), it is obvious that the boards have two thickness swelling components. The figures show the reversible and irreversible components of the board at each density and their combinations. At 1000kg/m^3, the irreversible thickness swelling of the boards was 21% and the reversible swelling was 8%.For 1200 kg/m^3, the irreversible thickness swelling of the boards was 15% while the reversible swelling was 8%. At the board density of 1300kg/m^{3}s, the irreversible thickness swelling of the boards was 16% and the reversible swelling was 9%. The thickness swelling in boards with the density of 1000 kg/m^3 increased more than boards with 1200 and 1300 kg/m^3.

It is therefore clear that the particleboard did not return to its initial thickness after soaking in water and redrying to the initial condition. Also the irreversible thickness swelling increased as the soaking and drying continues until it gets to a stage where further soaking and drying would not produce any further increase in the irreversible thickness swelling Fig. 4.4

Suchsland (1972) attributed such behaviour to the release of residual compressive stresses imparted to the board during the presses of the mat in the hot press. Subsequent redrying of the board after soaking resulted in thickness shrinkage which is equal to the shrinkage of the particle while none for the compressive stress released was recovered. This observation agreed with Beech's opinion (1975).

Conclusion

There was an increase in the thickness swelling and shrinkage of cement-bonded board made from wastepaper and sawdust when subjected to cyclic soaking in water and oven-drying for the first five cycle while a constant thickness swelling and shrinkage were maintained following further soaking and drying.

Additional wetting and drying circles resulted in further irrecoverable thickness swelling but at a decreasing trend. The thickness swelling in boards with higher density decreased with increase in water-soak and over-dry cycles compared with boards of lower densities before a constant thickness swelling are maintained.

Table 1: Mean values of cyclic water soak and oven dry conditions for seven cycles of cement-bonded particle board made from wastepaper and sawdust

Cement/wood ratio	Nominal density (kg/m3)	WSI	OD2	WS2	OD3	WS3	OD4	WS4	OD5	WS5	OD6	WS6	OD7	WS7
3.5:1	1000 1200 1300	9.52±1.53 6.89±4.27 5.75±1.99	4.63±1.33 2.08±0.57 2.48±0.74	16.26±1.72 11.2±1.68 12.56±2.38	12.15±1.60 7.09±1.79 8.18±2.35	22.77±1.93 17.15±1.69 18.84±2.03	19.83±1.91 12.89±1.67 14.61±2.15	28.12±2.25 20.49±1.67 21.74±2.24	21.47±1.96 14.57±1.59 16.05±2.24	31.33±2.06 22.87±2.05 24.31±2.225	21.88±1.98 14.63±1.59 16.10±2.24	31.58±1.00 22.99±2.10 24.51±2.22	21.99±2.00 14.68±1.59 16.16±2.24	31.63±2.34 23.17±1.99 24.71±2.27
3.0:1	1000 1200 1300	10.81±1.18 6.89±4.27 4.30±1.96	5.81±0.93 2.08±0.57 2.05±0.87	16.89±1.76 11.23±1.68 11.34±1.87	12.54±1.62 7.09±1.79 7.08±2.19	23.76±1.14 17.15±1.69 17.37±1.76	20.63±1.14 12.89±1.67 13.35±1.88	27.82±1.27 20.49±1.67 20.14±1.94	24.09±1.67 14.57±1.59 14.01±1.94	29.65±1.52 22.88±2.05 22.31±2.81	24.21±1.67 14.68±1.59 14.09±1.94	29.94±1.52 22.99±2.10 22.53±2.75	24.63±1.35 14.68±1.60 14.15±1.94	30.20±1.48 23.17±1.99 22.84±2.78
2.5:1	1000 1200 1300	11.31±1.96 6.04±3.80 4.40±0.50	6.05±1.36 2.59±0.47 2.06±0.30	15.83±2.06 13.36±1.55 11.50±0.63	11.52±2.03 8.16±1.52 7.64±1.35	20.60±1.77 18.87±1.51 17.95±0.61	17.64±1.67 14.74±1.36 14.03±0.86	23.38±1.68 22.23±1.49 21.93±1.49	19.85±1.58 15.75±2.12 15.68±1.44	24.83±1.43 24.81±1.89 24.49±1.77	20.08±1.62 15.08±2.13 18.20±0.87	25.19±1.39 24.99±1.86 24.73±1.91	20.18±1.60 15.86±12.12 18.31±0.89	25.63±1.37 25.16±1.85 24.97±1.79
2.0:1	1000 1200 1300	12.14±1.60 7.48±2.12 4.55±1.67	6.76±±0.87 3.741.33 2.16±0.69	16.88±2.19 14.02±1.31 11.50±1.80	12.11±1.20 9.19±±.10 1.751.50	21.72±1.95 20.07±2.20 17.45±2.40	18.53±1.79 15.93±2.05 13.40±2.28	24.67±1.81 22.85±1.92 20.70±2.51	20.01±1.68 15.76±3.20 14.05±12.36	26.28±1.87 25.61±2.15 23.01±2.56	20.09±1.67 15.82±3.19 14.18±2.36	26.96±1.93 25.74±2.18 22.70±2.33	20.49±2.41 15.89±1.19 14.29±2.35	27.39±1.86 26.09±2.32 23.54±2.54

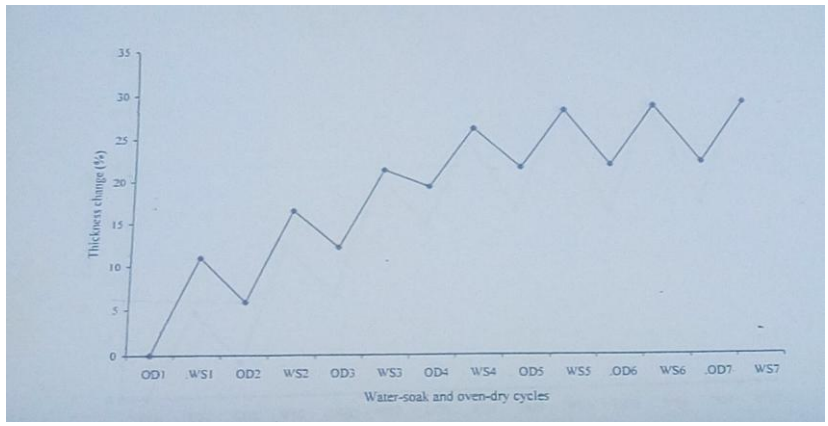

Fig 4.1: Thickness changes in water-soak and oven-dry cycles for 1000kg/m³ cement-bonded particleboard made from wastepaper and sawdust

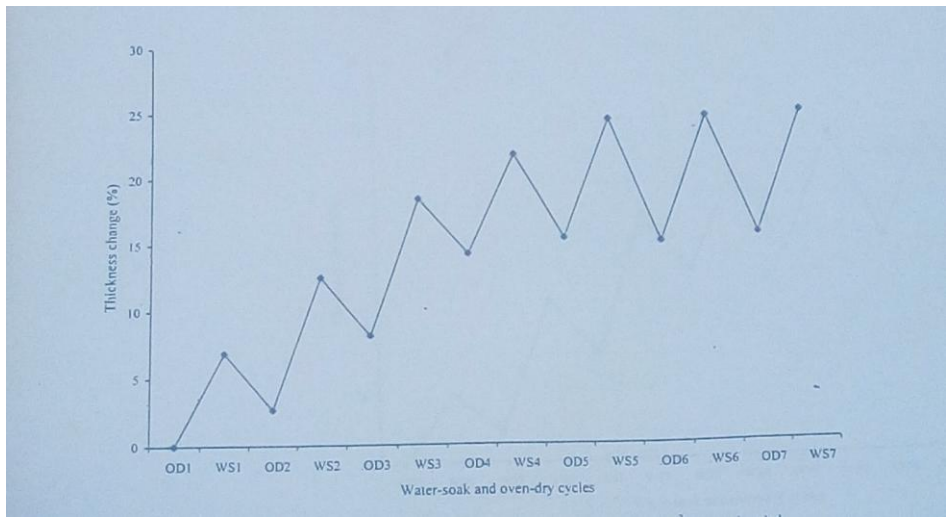

Fig 4.2: Thickness changes in water-soak and oven-dry cycles for 1200kg/m³ cement-bonded particleboard made from wastepaper and sawdust

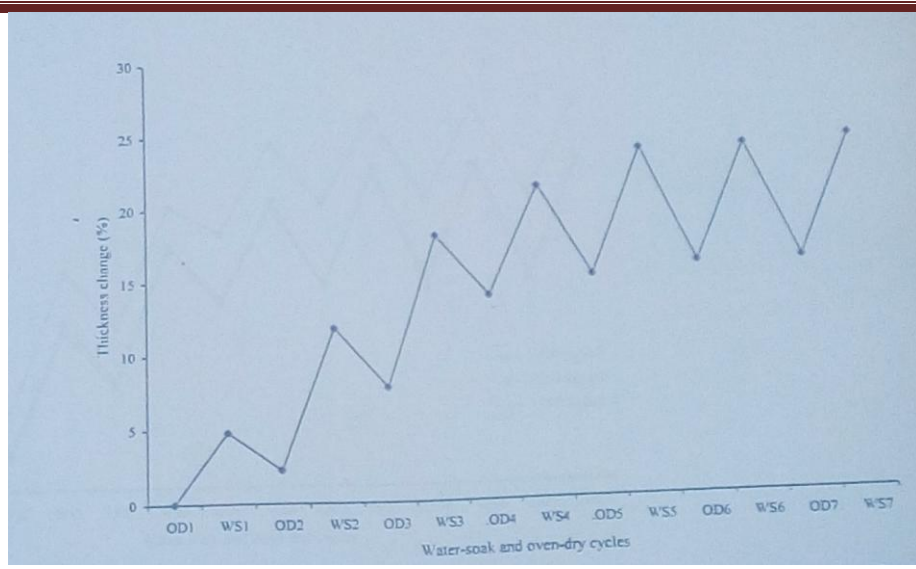

Fig 4.3: Thickness changes in water-soak and oven-dry cycles for 1300kg/m^3 cement-bonded particleboard made from wastepaper and sawdust

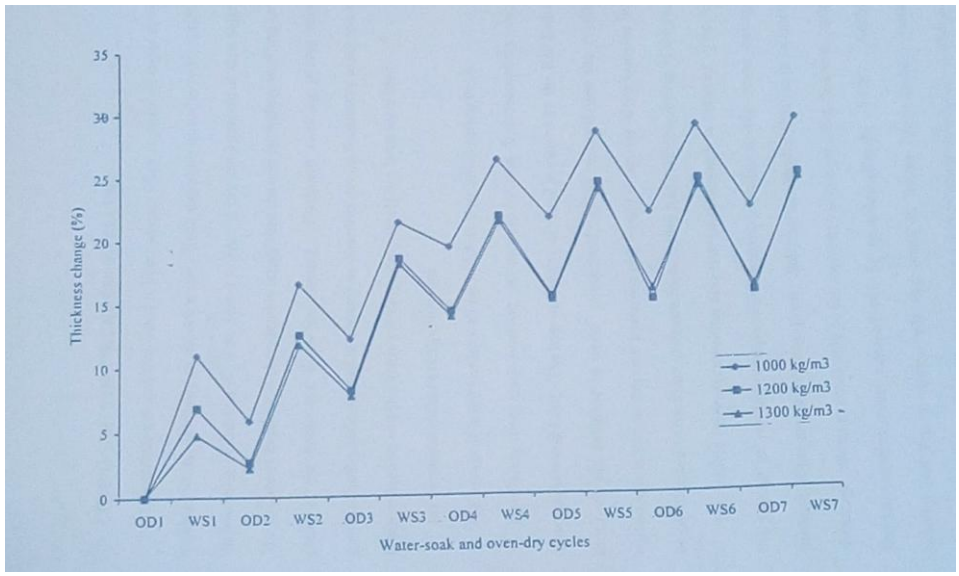

Fig 4.4: Thickness changes in water-soak and oven-dry cycles for cement-bonded particleboard made from wastepaper and sawdust

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