Effect of Pretreatment and Pressure on Properties of Cement-bonded Products from *Oxytenanthera abyssinica*

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Abstract

The study was designed to determine the effect of three water soaking periods of time (3, 7 and 10 days), three pressure levels (0.05, 0.1 and 0.15 kg/cm2) and three cement/bamboo ratios (2:1, 3:1 and 4:1) on mechanical and physical properties of bamboo-cement mixture. The effect of the three studied factors was dependent on each other for MOR and hardness. The results showed that all specimens met the specification of the British standard (BS 1105; 1972) for strength properties and the density of the product increased with increasing cement/bamboo ratio. Soaking in water for more than 7 or 10 days was either not significantly different from 3 days or had lower strength and density values; hence, no need for soaking in water for more than 3 days. Water absorption and dimension swelling decreased significantly with increasing cement/bamboo ratio. Also increasing of pressure from 0.05 kg/cm2 to 0.15 kg/cm2 did not improve the mechanical and physical properties.

Introduction

Cement-bonded wood products combine the best properties of cement and wood in one material. They are incombustible, weather proof, and resistant to deterioration from decay, insect and fire. They have good heat insulation and acoustic properties, low water absorbency, good dimensional stability, structural capability and good mechanical properties.

Wood-cement composite

In Europe, South America and Asia, cement has been used as bonding agent for wood excelsior board, particle board, fiber board and other wood cement composite products for nearly 50 years (Lee and Short, 1989). Lee (1984) concluded that cement excelsior board (CEB) was very stable dimensionally when subjected to water soaking, the water absorption and residual water absorption are much less than those of ply wood. Wood-cement panels are currently used in many countries for roof decking, flooring, exterior walls, partitions, and wall paneling in houses, school and industrial buildings (Hachmi and Moslemi, 1989).

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Effect of pretreatment on the properties of wood-cement products

Several reports indicate that some pretreatment of wood may improve wood-cement compatibility. Moslemi and Lim (1984) reported that hot extraction substantially improved the compatibility of twelve hard-wood species with cement.

Lee and short (1989) studied the affect of four pretreatment (water, $CaCl^2$, Na^2SO^4 and NaOH) on the bending properties of cement bonded hardwood and other pine excelsior boards. They found that boards made with water treated excelsior from cotton wood had the highest modulus of rupture (MOR) and MOE values while sweet gum excelsior boards had the lowest MOR and MOE values. Cold water extraction was sufficient to remove the inhibitory extractives from the 13 tropical species studied by Gnanharan and Dhamodaran (1985).

Effect of pressure on the properties of wood-cement composite

In early days, many methods were used to press the composite, e.g. pressing by concrete weight and left the composite under this pressure for about 25 hours, however with technological development the duration of pressing is reduced to 1/2 minutes using modern pressure or applying continues pressure between press rolls for half an hour (Moslemi, 1974). Lee (1984) used pressure of 400 Psi (28.16 kg/cm^2) for 24 hours.

Wood extractives and wood-cement compatibility

Many researchers concluded that extractive materials tend to prolong the setting time of Portland-cement as measured by the heat of hydration during cement setting (Weatherwax and Tarkow, 1964). The extractives present in Sudanese hardwoods are expected to cause problems for cement setting in manufacturing of cement-bonded boards. Suitable methods should be developed to remove or equalize the effect of these extractives.

The purpose of this work was to study the effect of some factors influencing the compatibility of bamboo with Portland cement. The specific objectives were to study the effect of soaking bamboo in water for 3days, 7days and 10 days) on the compatibility of bamboo with cement and to examine the effect of pressure on improving the properties of bamboo-cement mixture.

Material and Methods

The species used in this study was *Oxytenanthera abyssinica*, which is one of the two indigenous bamboo species available in the Sudan. Experiment was designed to study the effect of pressure and the duration of soaking bamboo in water on the properties of bamboo-cement mixtures. Three levels of Pressure were used, namely, 0.05, 0.1 and 0.15 kg/cm^2, these pressures were applied using a concrete. The three soaking durations used were 3, 7 and 10 days.

The appropriate amount of Portland cement and bamboo strands were weighed using a sensitive balance (Type PJ 6000, Mettler Toledo Ltd.) to constitute the three cement/bamboo ratios 2:1, 3:1 and 4:1. The amount of bamboo was taken on air-dry basis.

Portland cement and bamboo were first hand-mixed then water was added to the bamboo/cement mixture. For each treatment four specimens were prepared for each cement/bamboo ratio. Dimensions of the mold used here were 60*10*5 cm^3. The molds covered by wood to distribute equal pressure in specimens, the different levels of pressure were exerted by simply putting concrete weight on the specimens. Polycine sheet was used to cover the mold for minimizing evaporation. The molded sample were kept in the molds under pressure for 24 hours and then removed from the mold, and left to cure for 28 days. These specimens were used to determine the modulus of rupture (MOR) using a universal testing machine (SIEMENS R 920 e.g. 1116). Maximum load reading was taken and MOR calculated using the formula 3PL/2bd2 where P = maximum load, L = length of sample, b = width and d = thickness of sample. Samples for compressive strength and density tests were cut from the ends of the MOR specimens. The size of the sample for the compressive strength measured 5*5*5 cm^3. Using the universal testing machine, maximum load required to crush the cubes was recorded in kilograms and compressive strength was calculated by dividing the maximum load by the cross sectional area of the samples. The test was carried out a according to the specification of the British standards (BS/12, 1958) for testing compressive strength of cement using mortar cubes.

Another set of specimens was cut out of the MOR specimens and used to determine the density, water absorption and dimensions stability. Density was measured based on the oven dry weight and green volume.

Water absorption after 24 hours = (Wt 24-Wt dry)/W dry *100% where
Wt 24 = weight of sample after immersion in water for 24 hours
Wt dry = Air-dry weight of sample.

Dimensional stability was determined by measuring the length, width and thickness of sample in centimeter (cm) on air-dry condition and after immersion of samples in water for 24 hours using the following formulas:

Length swelling % = (Ls-L)/L * 100%, Width swelling % = (Ws-W)/W * 100% and Thickness swelling % = (Ths-Th)/Th * 100%

Where:
L = Length of sample on air-dry condition.
W = Width of sample on air-dry condition.
Th = Thickness of sample on air-dry condition.
Ls = Length of sample after swelling.
Ws = Width of sample after swelling.
Ths = Thickness of sample after swelling.

Results and Discussion

The effect of cement/bamboo ratio was significant on the strength properties (MOR, compressive strength and density) of the bamboo-cement mixtures. Generally the strength values showed an increasing trend as the cement/bamboo ratio was increased from 2:1 to 4:1 (Figure 1), this in line with finding of Abdalla (1998), that the increase of MOR for Sunt wood-cement mixture was associated with increase of cement : wood ratio.

Soaking time also had significant effect on MOR and density, but it had no significant effect on compressive strength. There is no need to soak bamboo in water more than 3 days at cement/bamboo ratios up to 4:1 and low applied pressures up to 0.15 kg/cm^2. Effects of soaking time depend on cement/bamboo ratio for density (Table 1). Bamboo-cement composite had lower density value (486.13-944.3 kg/m^3), while

Malony (1989) found that wood-cement composite densities usually range between 900 to 1400 kg/m^3.

The effects of the three factors (soaking time, cement/bamboo ratio and pressure) depend on each other for the MOR of the bamboo-cement mixtures. Table 2 shows the effect of water soaking on dimensions swelling (%). No significant effects were found for soaking time on dimensional swelling (0.210- 0.394 %) of bamboo-cement mixtures. This agrees with fact that cement-bonded wood products have good dimensional stability, and this is considered as desirable properties. Cement/bamboo ratio and soaking time had significant effect on water absorption after 24 hours. The water absorption decreased with increasing cement/bamboo ratio from 2:1 to 4:1 (Figure 2), this may be due to the increase in the mounts of cement surrounding bamboo particles. High strength properties values obtained at high cement/bamboo ratio 4:1 with all combinations of pressure and soaking time, this ratio also showed the least amount of water absorption. Soaking for 3 days had good results on mechanical and physical properties, thus there is no need for soaking bamboo in water for more than 3 days.

For most of the mechanical and physical properties no differences were observed between three pressure levels applied in this study; this may be due to the low pressure levels used in this study (Table 3).

Conclusions

1. The MOR values of specimens produced using all pre treatments met the specification of the British Standard (BS 1105; 1972).
2. Soaking in water for 3 days is long enough to improve the strength properties (MOR and compressive strength).
3. Bamboo-cement composite had lower density value compare to other wood-cement composite.
4. The water absorption was decreased with increasing cement/bamboo ratio.

Recommendation

Bamboo is suitable for manufacturing Bamboo–cement products, which is used as wall paneling, roofing, partitions and others. Soaking Bamboo in water for 3 days was quite enough to be applied in this manufacture.

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Fig. 1: Effect of Cement ; bamboo ration by soaking time in MOR

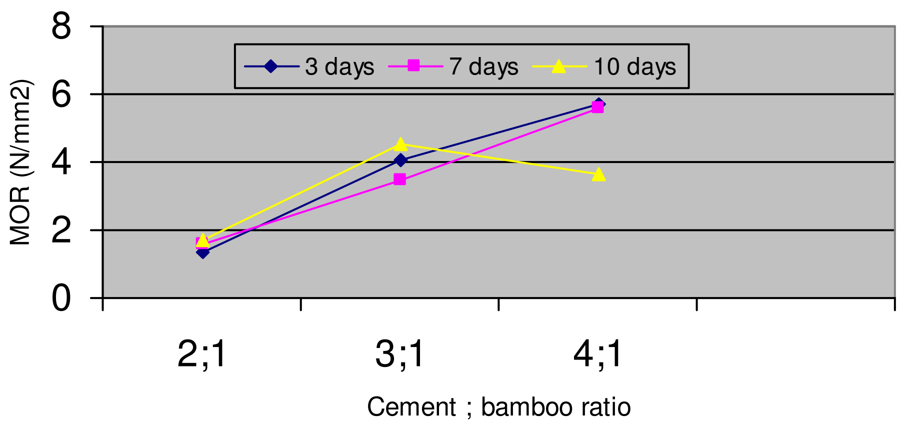

Table 1. Effect of cement/bamboo ratio and water soaking on density (kg/m^3)

Water soaking time	Cement/ bamboo ratio		
	2:1	**3:1**	**4:1**
3 days	486.13^{c}_{a}	639.32^{b}_{a}	944.3^{a}_{a}
7 days	537.92^{c}_{a}	733.83^{b}_{b}	856.56^{a}_{b}
10 days	554.93^{c}_{a}	803.37^{b}_{b}	816.91^{a}_{b}

In the same row, means with the similar upper case letter (s) are not significantly different at P = 0.05. In the same column, means with similar lower case letter (s) are not significantly different at P = 0.05.

Table 2. Effect of water soaking on dimensions swelling (%)

Water Soaking time	Dimensions		
	Length %	Width %	Thickness %
3 days	0.285 a	0.237 a	3.123 a
7 days	0.289 a	0.210 a	0.370 a
10days	0.584 a	0.394 a	0.328 a

In the same column, means with the same letter (s) are not significantly different from each other at P = 0.05.

Fig.2. Effect of cement:bamboo ratio on water absorption (%)

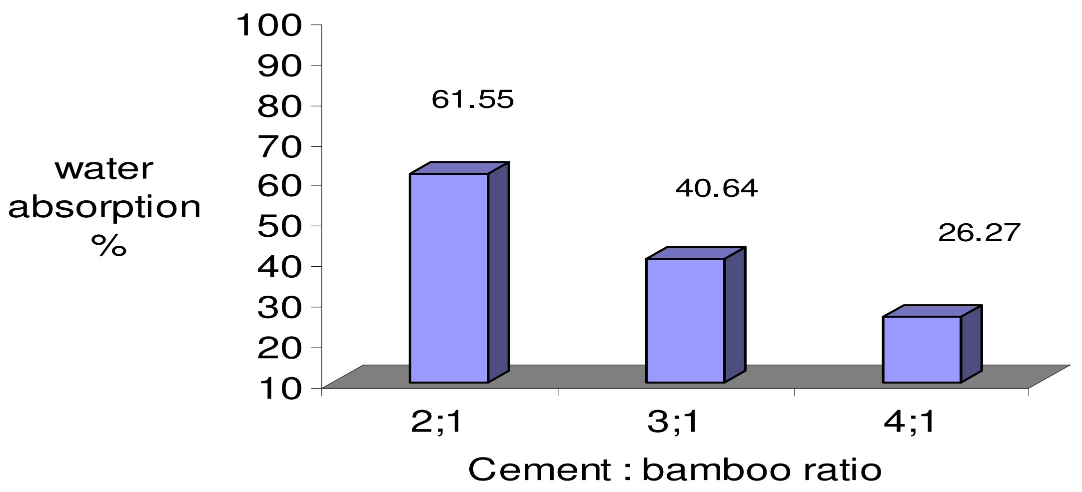

Table 3. Effect of pressure on properties of bamboo-cement mixture

Pressure (kg/m^2)	Compressive strength (N/mm^2)		Density (Kg/m^2)		MOR (N/mm^2)	
P1 = 0.05	9.72	a	703.0	a	4.04	a
P2 = 0.10	9.85	a	728.9	a	3.5	a
P3 = 0.15	10.14	a	690.8	a	4.25	a

In the same column, means with same letters are not significantly different at P = 0.05.