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A PRELIMINARY EVALUATION OF THE FLEXURAL PROPERTIES OF WOOD VENEER LAMINATED CEMENT-BONDED PARTICLEBOARD FROM TROPICAL HARDWOOD SPECIES

By

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Introduction

Wood-cement bonded particleboard was originally invented in Germany about eight decades ago. Since then, it has been gaining acceptance in many parts of the world as a sheet element for the building construction industry. The interest in the board can be associated with a number of factors. It is highly resistant to fire, insect aud fungal attack and has excellent weatherability and good accoustic insulation properties (Deppe, 1974; Dinwoodie, 1978; 1981). With respect to the aforementioned properties, the board is superior to the conventional resin bonded particleboard. Thus, the cement board is being applied to complement resin boards in areas where adverse weather conditions and fire preclude the use of the latter. The cement board is also more favoured than the resin board by having one of its principal raw material, namely cement, locally available in most countries, and by the fact that its manufacture is more easily adapted to a relatively small plants.

One of the major problems of cement-bonded particleboard is the poor bending strength. This is a serious limitation to its use for load-carrying purposes. Thus, in order to gain a wider acceptance as a structural panel for the building industry, there is the need to develop means of improving the strength properties of the board. The main purpose of this preliminary study, therefore, is to address the strength problem of wood-cement bonded particleboard. Specifically, the objective of the study is to examine the effect of wood veneer lamination on the flexural properties of the board at different cement wood ratios and board densities.

Materials and Method

Plantation grown *Gmelina arborea* wood and mixed sawdust of some hardwood species were used in this study. Following felling, the Gmelina wood was cross cut into bolts and debarked. The debarked bolts were seasoned for eight weeks, and thereafter cut into flakes of about 25 mm in length and 0.25 mm thickness. The sawdust was sieved using 6 mm and 2 mm mesh screens. The flakes, and the portion of the sawdust which passed through 6 mm screen but retained on 2 mm mesh screen were separately subjected to hot water treatment at a temperature of 75°C. The wood materials were so treated to remove water-soluble extractive component of the wood. Following extraction, the flakes and the sawdusts were airdried to 12 percent moisture content prior to panel fabrication.

Ordinary Portland cement was used as binding agent while Calcium chloride, 3 percent weight of cement, was incorporated in the wood particle-cement paste mix to accelerate cement curing. The cement was purchased locally from a fresh consignment in standard bags of 50 kg weight. It was a general purpose type complying with BS 12, Part 2: 1971.

The experimental boards were fabricated at three nominal board densities viz: 1000, 1100 and 1200 kg/m³ (based on ovendry weight of the board), and at cemeut/wood ratios of 2.50:1, 2.75:1 and 3.00:1 (weight to weight basis). The study variables were combined in 3 by 3 factorial layout. Each treatment combination was replicated two times.

Prior to board fabrication, the amounts of cement and wood particles required for the production of each board were calculated on ovendry weight basis. The calculation of the quantities of the materials for the board was done separately for the face and the core, and in such a way that the thicknesses of each of the two face layers, and of the core layers in the final board will be 1.5 mm and 9 mm respectively. The amount of water needed was estimated from the following relationship developed by Simatupang (1979).

$$\text{Volume of water (ml)} = 0.35C + (0.30 - MC)\,W$$

where: C = Cement weight (g)
MC = Wood moisture content (%)
W = Wood weight (g)

For each board, the required quantity of wood particles and water containing dissolved Calcium chloride were mixed manually before cement was gradually added. The ingredients were thoroughly hand mixed until the mixture appeared to be homogeneous. The wood flakes for the core layer of the experimental board and the sawdust for the face layers were separately mixed. The cement-wood particle mixes were then evenly distributed by hand onto a caul plate to form a mattress. In forming the mattress, half of the cement-sawdust mix was first spread onto the caul plate, followed by the cement-wood flake mix and lastly, the remaining half of the cement-sawdust mix. After forming, another caul plate was placed on the mattress and it was cold pressed in an hydraulic press to the required thickness of 12 mm with a pressure of 1.23 N/mm². The mattress was left under this pressure for a period of 24 hours in order to hold the cement paste coated wood particles together while cement hydration takes place. At the end of this period, each board was released from pressure and stripped from the caul plate. In order to reduce water loss from the board formed and enhance further hydration of the cement binder, the boards, immediately following stripping, were sealed up in polythene bags for 28 days. Thereafter, the boards were conditioned at 60 percent relative humidity, at 20°C to a constant weight.

After conditioning, each board was cut into two halves to give two sets of boards. One set of boards was laminated with 0.6 mm thick wood veneer while the other set was left unlaminated. The lamination was done using 1.43 g/m² (double glue line) of cold setting urea formaldehyde resin. After gluing, and following an open assembly time of 15 minutes, the veneers were laid on the board surfaces and cold pressed for 8 hours at the pressure of 1.23 N/mm². The laminated boards were conditioned at 60 percent relative humidity and 20°C for 14 days. Both the laminated and non-laminated boards were tested for static bending performance in accordance with German Standard DIN 68761 (1967).

Result and Discussion

The Modulus of Rupture (MOR) and Modulus of Elasticity (MOE) of the wood veneers laminated and non-laminated cement-bonded wood particleboards prepared at different cement wood ratios and board densities are presented in Table 1.

Table 1

Flexural properties of wood veneer laminated and non-laminated cement-bonded board at different cement wood ratios and density levels

Cement Wood Ratio	Nominal Density (kg/m³)	Observed Density (kg/m³)	Modulus of Rupture (MPa) Non-Laminated	Laminated	Modulus of Elasticity (MPa) Non-Laminated	Laminated
2.5:1	1000	988	5.71	27.17	1079	3335
2.5:1	1100	1089	8.56	30.20	1481	3823
2.5:1	1200	1230	11.50	36.07	2100	4497
2.75:1	1000	993	7.45	28.32	1285	3424
2.75:1	1100	1114	9.22	32.53	1553	3913
2.75:1	1200	1245	12.62	41.32	2198	5074
3.0:1	1000	991	7.77	27.93	1400	3372
3.0:1	1100	1120	10.15	35.59	1875	4237
3.0:1	1200	1249	14.30	42.55	2418	5211

Each value represents the mean of two replications.

It is obvious from the Table that the three variable factors in this study namely: cement wood ratio, board density and lamination have considerable influence on both the MOR and MOE of the board. The values of MOR ranged from 5.71 to 14.30 MPa for the non-laminated board, and from 27.17 to 42.55 for the laminated board. For MOE the values are in the range of 1079 to 2418 MPa, and 3335 to 5211 MPa for the non-laminated and laminated boards, respectively. The observed improvement in the flexural properties as a result of wood veneer lamination of the board is approximately two to three-fold increase in the properties of the unlaminated boards. As earlier noted, the strength properties of the board which include MOR and MOE are important properties which determine the applicability of particleboard for structural component. Thus, on the basis of the improvement in the flexural properties observed, lamination with wood veneer can be considered as a way to enhance the boards utilization as a structural component in the building industry.

Both the MOR and MOE increased with increase in board density and cement wood ratio. This observation agrees with reports by previous workers (Moslemi *et al*, 1983; Badejo, 1988 and Oyagade, 1989). The influence of increasing density can be associated with improvement in stress distribution within the board as a result of better interparticle contact caused by the increase in board density. Also, with increase in cement/wood ratio, more cement was available for interparticle bonding, leading to enhancement of the board mechanical properties.

Conclusion

Within the range of study variables employed in this study, Modulus of Rupture and Modulus of Elasticity of cement bonded particleboard increased with board density, cement wood ratio and lamination. The lamination of the boards brought about two to three times increase in the strength propetries of the board. The wood veneer laminated boards, particularly those produced at cement wood ratio in the range of 2.5:1 to 3.0:1 and density of 1200 kg/m^3 could be satisfactorily used as a semi structural material in the building construction industry.

Summary

Cement bonded wood particleboards were made using tropical hardwood species at three nominal density levels of 1000, 1100 and 1200 kg/m^3 and cement/wood ratios of 2.5:1, 2.75:1 and 3.0:1. The boards were manufactured at nominal board thickness of 12 mm and comprised three layers with 0.25 mm thick flakes for a 9 mm thick core layer and sawdust for 1.5 mm thick face layers. One set of boards was laminated with 0.6 mm thick wood veneer while another set was not laminated. The static bending (Modulus of Rupture) values for non laminated and laminated boards ranged from 5.71 to 14.30 MPa and 27.17 to 42.55 MPa respectively.

For bending stiffness (Modulus of Elasticity), the observed values ranged from 1079 to 2418 MPa for the non-laminated board, and 3335 to 5211 MPa for the laminated boards. Generally, the increase in the values of the flexural properties caused by lamination is about two to three times the values observed for non-laminated boards. The boards were stronger and stiffer with increase in cement wood ratio and board density.

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