THE PROPERTIES OF RECONSTITUTED PANEL MANUFACTURED FROM OIL PALM FRONDS

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ABSTRACT

The reconstituted panels were manufactured from oil palm fronds for different board densities (560 kg/m^3 to 800 kg/m^3) and tested for various properties such as modulus of rupture (MOR), modulus of elasticity (MOE) and thickness swelling. The modulus of rupture (MOR) of the board at 10% resin level was 27.3 MPa, 26.6 MPa, 47.5 MPa and 96.0 MPa at densities 560 kg/m^3, 640 kg/m^3, 720 kg/m^3 and 800 kg/m^3 respectively. This is equivalent to 30% to 90% of the average equivalent solid wood. The boards retained 30% to 60% of their strength and 70% to 90% of their stiffness after soaking in water. Thickness swelling decreased from 51% to 23%, and water absorption decreased from 152% to 59% when board density increased from 560 kg/m^3 to 800 kg/m^3.

Key words: modulus of rupture, modulus of elasticity, thickness swelling, density

INTRODUCTION

The oil palm or *Elaeis guineensis,* brought into Malaysia from Africa as an ornamental plant, is now a very important commercial crop, with a planted area of 2,819,000 hectares in 1997. It earned for Malaysia nearly RM13 billion in export that year, and is obviously an important cash crop for Malaysia. The principal product is palm oil. Currently only a tiny 15% of the biomass production in the plantation is palm oil. The rest of the biomass is under-utilized. By products of the oil palm industry consist of shells, empty fruit bunches, pressed fruit fibers (mesocarp fibers) palm oil mill effluent (POME), oil palm trunks and fronds. Oil palm stands are felled after an economic life span of 25-30 years. Replanting make available a large quantity of oil palm frond with its attendant disposal and environmental problems. In 1997, replanting of oil palm yielded over 27 million tons of biomass, of which a very significant portion is oil palm frond. Felled stems and fronds are known to be a favorable focus for diseases and pests, such as basal stem rot, Ganoderma and rhinoceros beetles. Burning is the most convenient means of disposal but causes much air pollution. During harvest, some fronds are pruned to facilitate access to the fruits. The quantity of fronds generated by pruning is in the order of a few times greater than frond or trunk generated through replanting. Based on an estimated planted area of 2.819 million hectares and around24fronds pruned annually, the quantity of pruned fronds in 1997 is 12.86 million tons dry weight. Currently pruned fronds are used for inter-row mulching. These rotting fronds attract pests such as rats and snakes. Current disposal methods caused much environmental problems (Anon. 1998).

The amount of oil palm trunks and fronds residues is expected to increase to 7.0 million-ton and 26.2 million ton by the year 2000 (Salleh 1994). There is an urgent need to find a practical and economical means of utilization of such a huge amount of agricultural residues. The utilization of the pruned fronds should receive more attention because of its easy availability and greater quantity as compared to the oil palm trunk.

The objective of this study are to try to strike out in a new direction from making conventional particleboard or MDF and attempt to make a reconstituted panel with properties similar to solid wood. Another objective is to try to make a panel without going through the tedious process of separating the parenchyma cells.

LITERATURE REVIEW

Current research efforts on utilization of the oil palm trunk and fronds are mainly directed at making conventional panel products such as particleboard, medium density fiberboard (MDF) and cement particleboard. Single layer 19mm UF particleboard from palm stems with densities from 500 to 820 kgm3 had modulus of rupture ranging from 10 to 20 MPa. and thickness swelling from 4 to 8% (Chew *et al.* 1985). Particleboard made from oil palm empty fruit bunches were slightly stronger with MOR ranging from 20 to 25 MPa. but thickness swelling was also higher at 21 to 37% (Shaikh *et al.* 1994). Maylor, Mohd. Nor and Koh(1994) found that MDF made from OPT and EFB at density of about 700 kg/m3 has MOR of 18 to 21 and 15.3 to 15.4 MPa. respectively, while those made from oil palm frond ranged from 16 to 21 Mpa. Thickness swelling was in the region of 13 to 22%. Mohd Nor, Md. Zin and Wan Roshdan found that MDF made from 100% oil palm frond and density 677 kg/m3have MOR of 13 Mpa. and thickness swelling of 19% (Mohd Nor 1994). Liew and Razali(1994) fabricate MDF from OPT with isocyanate and MUF binders and board densities from 500 to 700 kg/m3. The boards had sry MOR ranging from 7 to 20 MPa. and dry MOE ranging from 1100 to 2800 MPa.. After soaking in water the strength values ranged from 30 to 50% of the corresponding dry strength.

MATERIALS AND METHODS

Materials Preparation

Freshly felled oil palm fronds were collected from an oil palm estate at Bukit Raja Klang, Selangor. An adhesive factory prepared the low molecular weight phenol formaldehyde resin solution with about 42% solid content. The degree of polymerization was estimated to be less than 10.

Board making and Testing

The leaflets were removed from the central rachis. The rachis was crosscut into 340mm lengths. The rachis was 'debarked' and the remaining pith was split into slats of approximate dimensions 340mm x 5mm x 5mm. The slats were subjected to successive cycles of compression rolling and soaking in water to reduce the sugar and starch content. No attempt was made to separate the parenchyma cells from the vascular bundles. The slats were subjected to a last cycle of compression rolling to reduce the moisture content to aid subsequent absorption of the resin solution.

The solid content of the resin solution was reduced to about 3.5% through dilution with water. The rolled slats were soaked in the diluted solution for about 12 hours and subsequently dried at 60°C to moisture content less than 10%. The pre-dried saturated slats were formed into a mat with the aid of a wooden former with all fibers aligned parallel, cold pressed for 2 minute followed by hot pressing to 12mm stops at 180°C for 5 minutes to target densities 560, 640 and 720 kg/m^3, except for the 6mm board which were pressed at 180°C for 3.5 minutes target density 800 kg/m^3.

The boards were conditioned over saturated salt solution for about 2 weeks. Bending strength and water absorption samples were prepared and tested according to Japanese Industrial Standard for Particleboard JISA5908 (Anon. 1994).

RESULTS AND DISCUSSIONS

The boards produced in manners described above had very pleasing simulated wood-grain appearance with a yellowish-brown colour, perhaps almost like mahogany. The high density boards have hardly any void in its structure and appear very much like solid wood with lustrous surfaces, clean edges and ends.

The results of the bending strength and water absorption tests are summarized in Table 1.

The results of the bending strength tests were compared to the average bending strength of air-dry solid wood obtained by regression analysis of available data on the strength properties of Malaysian timbers (Lee *et al.* 1979). The result of the comparison is shown graphically in Figure 1 and Figure 2.

The results of the bending strength test show that panels with very satisfactory properties can be made from oil palm fronds, especially at higher densities. Boards pressed to density 800 kg/m^3, for example, had bending strength of 96 MPa and modulus of elasticity almost 9000 MPa. This is equivalent to about 90% and 55% of the average solid wood equivalent estimated to be 105 MPa and 16000 MPa respectively (Lee *et al* 1979). After 2 hours soaking in water at 70°C and 1 hour in room temperature water, the boards strength were reduced to 30% to 60% of their dry values in the case of the modulus of rupture, and 70% to 90% of their dry values in the case of the modulus of elasticity (Graph 3).

TABLE 1. Flexural properties and thickness swelling of reconstituted panel from oil palm frond

DENSITY (kg/m^3)	560	640	720	800
DMOR (MPa)	27.3	26.6	47.5	96.0
WMOR (MPa)	8.14	9.90	13.6	56.5
WMOR (%)	30	37	29	59
DMOE (MPa)	3730	4660	5420	8980
WMOE (MPa)	2560	3600	4700	8220
WMOE (%)	69	77	87	92
THICKNESS SWELLING (%)	50.7	52.8	38.4	23.4
WATER ABSORPTION (%)	152	140	101	59.3

Notes: DMOR = Dry Modulus of Rupture
WMOR = Modulus of Rupture after soaking in water
DMOE = Dry Modulus of Elasticity
WMOE = Modulus of Elasticity after soaking in water

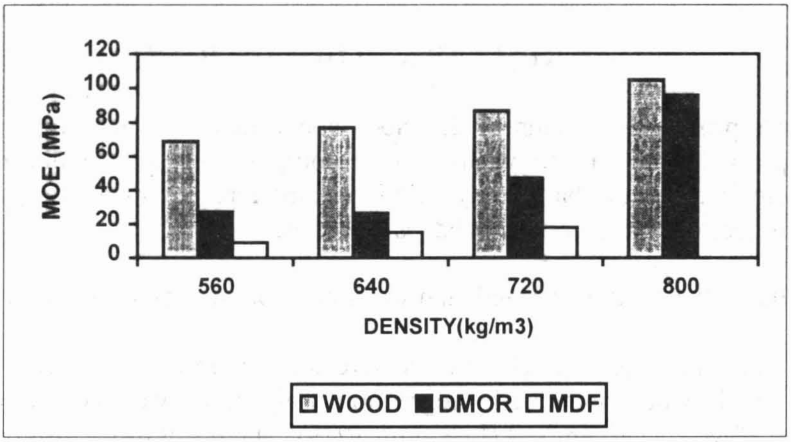

FIGURE 1: Bending strength values (MOE) at various densities

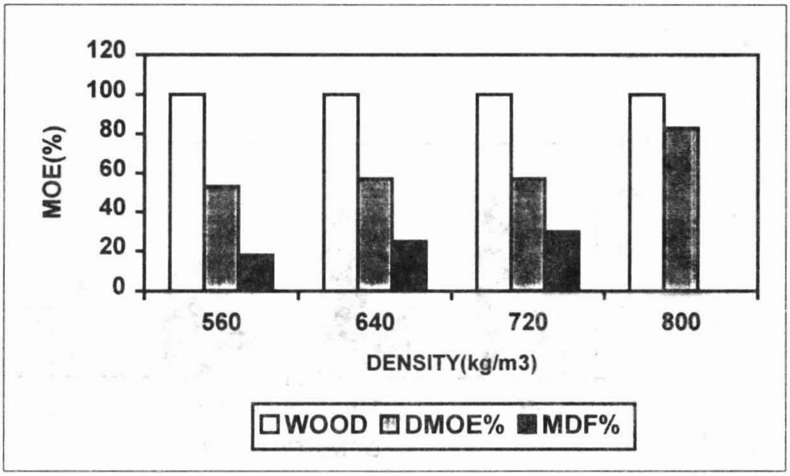

FIGURE 2: Modulus of Elasticity as percentage of solid wood

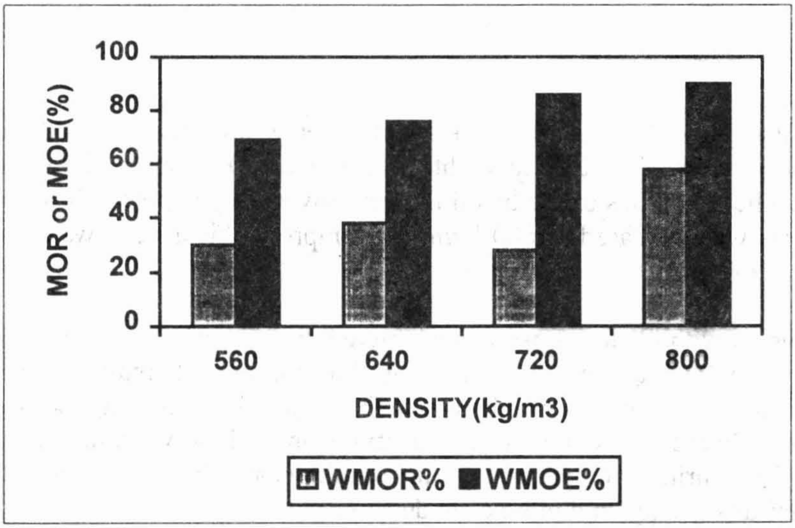

FIGURE 3. Strength retention at different densities after soaking.

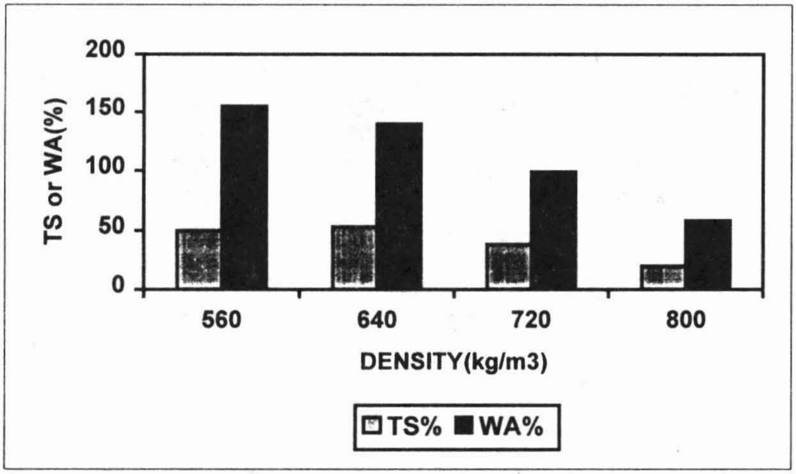

FIGURE 4: Thickness swelling (TS) and water absorption (WA) at different densities

Thickness swelling after 2 hours soaking in water was on the high side, ranging from 50% for the low-density boards to slightly higher than 20% for the higher density boards (Figure 4). The properties of the board thus improved very appreciably when the density of the boards was increased to 800 kg/m^3. To improve this aspect, wax may have to be added to the furnish.

Some problems with blistering were encountered during hot pressing with the 6 mm 800 kg/m^3 boards, indicating that for high-density boards, the slats may have to be pre-dried to lower moisture content. No problems with blistering were encountered with the 12 mm lower-density boards. The boards underwent some slight warping, probably due to difficulties in ensuring even density throughout the board. Ways will have to be found to ensure better distribution and more even density.

CONCLUSION

Reconstituted panels with very satisfactory strength properties can be made from oil palm frond, with values for high density boards approaching 90% and 55% of the average modulus of rupture (MOR) and modulus of elasticity (MOE) of equivalent solid timber. Strength and stiffness increase with board density.

The MOR was reduced to 30% to 60% of their dry values, and the MOE to 70% to 90% of their dry values after soaking in water, the percentage increasing with board density. The thickness swelling decrease from 50% to 23% when board density increase from 560 kg/m^3 to 800 kg/m^3. Thus, resistance to water increases with increasing density.

Very acceptable reconstituted panel can be made from oil palm frond by consolidating it to high density, but the furnish need to be pre-dried to a lower moisture content to avoid blistering.

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