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MANUFACTURE AND PROPERTIES OF COMPOSITE BOARDS MADE FROM KENAF

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SUMMARY: The increasing demand for wood-based board products, together with the need to maintain wooden raw material resources, has become an important problem in Japan. Fear of shortage in wood supply from export countries has led to serious search for alternative raw materials, such as Kenaf (*Hibiscus cannabinus* L.). Kenaf is a fast-growing year-round economic plant used for coarse textiles and in papermaking.

In this study, two types of composite boards were manufactured using kenaf stalk and sugi (*Cryptomeria japonica* D. Don) chips gathered from small diameter thinnings. Type 1 boards were produced using kenaf stalk and sugi chips, as core and surface materials, respectively. Type 2 boards were produced using kenaf stalk only in both core and surface layers that were oriented perpendicular to each other.

The kenaf-composite boards were tested and evaluated the modulus of rupture (MOR), modulus of elasticity (MOE) in bending, internal bond (IB), water absorption (WA) and thickness swelling (TS). Result of experiment indicated that technical feasibility of producing the two types of kenaf-composite boards with properties suited for particular end-uses.

KEYWORDS: Kenaf (*Hibiscus cannabinus* L.), Sugi (*Cryptomeria japonica* D. Don), Composite Boards, Mechanical Properties, Dimensional Stability

INTRODUCTION

The present demand for wood-based products is rising and the maintenance of wooden raw material resources has become an important problem. Especially in Japan, where there is a high dependence on imported resource, fear of shortage due to the logging ban and export restriction in many countries led to the search for alternative resource [1-3]. Kenaf has recently been the target of attention because of a fast-growing year-round plant. Kenaf is an economic plant used for textiles and in papermaking. The stalk has bark that covers the low-density (parenchymatous) core and the pith, which is usually hollow. Many types of boards utilizing the characteristics structure of kenaf have been investigated [4-6].

In this study, two types of three-layer boards were made using kenaf stalk as shown in Fig. 1.

Type 1 boards were produced using kenaf stalk and sugi chips as core and surface materials, respectively. Type 2 boards were produced using kenaf stalk only in both surface and core layers that were oriented perpendicular to each other.

Materials and Methods

Kenaf were harvested from the field in Tottori, Japan. The stalks were dried to about 13% moisture content (MC). Then cut into 300 mm length pieces.

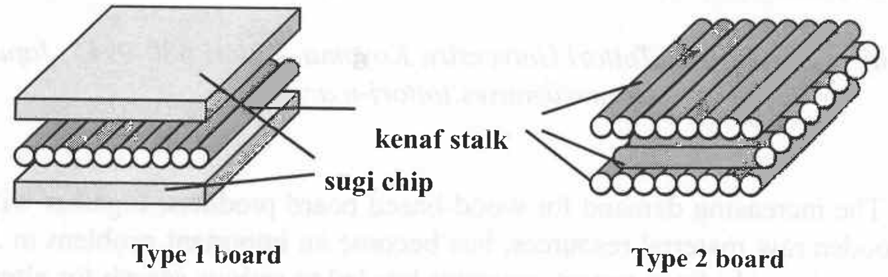

Figure 1 Boards Structure

Board type1: Composite boards made from kenaf stalks and sugi chips

For this type of board, the kenaf stalks were used as core material. These were classified according to their diameter (Ø), namely, S for 5-12 mm Ø, M for12-18 mm Ø, and L for 18-25 mm Ø. On the other hand, sugi chips were produced using flaker. The average chips size and density were 10 (L) x 30 (W) x 0.1-0.2 (T) mm and 0.33 g/cm^3, respectively. Boards with six different compositions were manufactured by mixing at various weight ratios shown in Table 1. The binder was Isocyanate resin (Oshika Co., PB-1605), used at 8 % resin content. Boards were pressed at a maximum temperature of 170°C and pressure of 10 kgf/cm^2 for 6 minutes. Thickness bar was used to obtain the target board dimensions of 300 x 300 x 10 mm. The manufactured boards were then conditioned at 20°C and 65 % relative humidity to maintain the moisture content at 11 %. After one week the modulus of rupture (MOR), modulus of elasticity (MOE), internal bond strength (IB), water absorption (WA) and thickness swelling (TS) were measured following JIS A 5908 method.

Table 1 The composition of Type 1 Board

cugi chip:kenaf:cugi chip		kenaf diameter (mm)		
		S	M	L
		5~12	12~18	18~25
I	0.5:1.0:0.5**	I-S*	I-M*	I-L*
II	0.25:1.0:0.25**	II-S*	II-M*	II-L*

*: board type symbol
**: weight of materials

Board type 2: Three-layer composite board using kenaf stalks

For this type of board, the stalks were used in all three layer of the board. The stalks were arranged such that the core layer was perpendicular to the surface layer. The binder was Isocyanate resin (Oshika. Co., PI-bond 400) used at 4% resin content. Press temperature was varied at 150, 170, and 200°C at a maximum pressure of 25 kgf/cm^2 and 10-13 min pressing time. Thickness bar was used to obtain a board with dimensions 300 x 300 x 10 mm. The manufactured boards were then conditioned at 20°C and 65 % relative humidity to maintain the moisture content at 11 %. After one week the properties of the boards were determined as in the previous experiment. In the case of the bending strength, tests were performed parallel and perpendicular to the orientation of the surface layer stalks.

RESULTS AND DISCUSSIONS

Board type 1: Composite boards made from kenaf stalks and sugi chips

All boards surface are homogeneous surface due to the sugi chips. The cross section through the board shows the flattened radial section of the kenaf stalks with sugi chips filling in spaces between stalks. The effect of such structure on board density is shown in Fig. 2. In general, boards density varied with the diameter of the kenaf stalks. To wit, boards with L size kenaf stalks (I-L and II-L) are low in density apparently due to greater space occupied by each single low-density (0.22 g/cm^3) stalk. Consequently, II-L boards with large size stalks and smaller proportion of sugi chip exhibited the lowest board density.

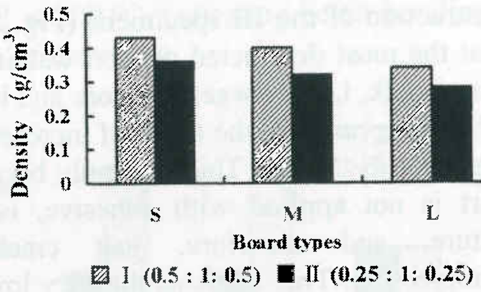

Figure 2 Density of Type 1 boards

Figs. 3(a) and 3(b) show the MOR and MOE values, respectively, of the boards. Values differed greatly according to orientation of the stalks in the core layer of the board, with the perpendicular (⊥) values being about five times greater than the parallel (ll) values.

In addition, values are higher with small diameter stalks due to the greater number of stalks that reinforced each board.

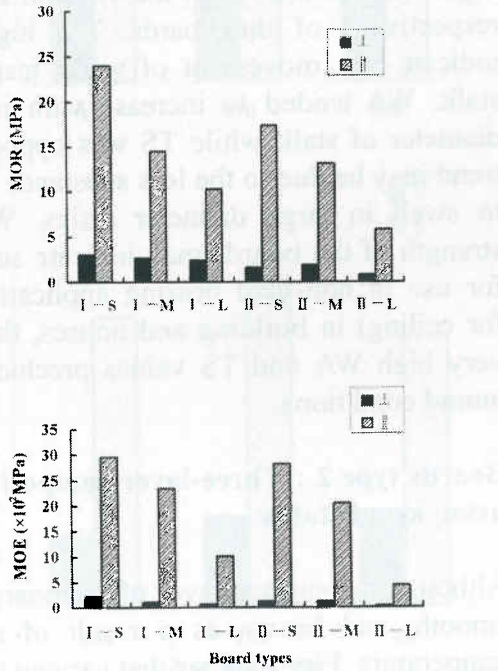

Figure 3 (a) MOR and (b) MOE of Type 1 boards

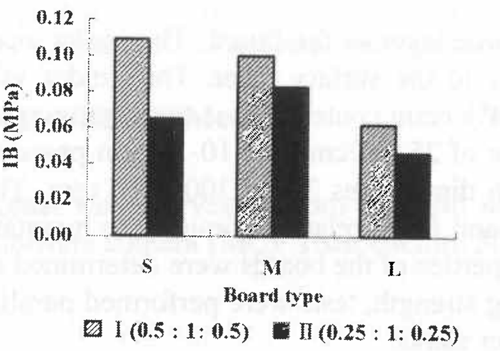

Figure 4 IB strength of Type 1 boards

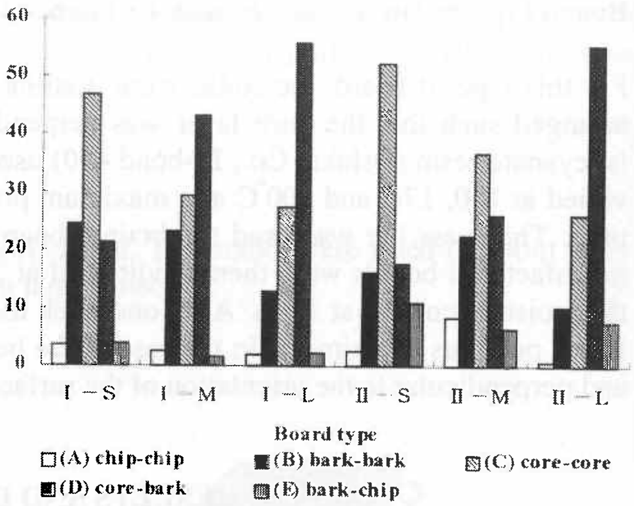

Figure 5 IB analysis of Type 1 boards

As with MOR, IB values are also generally higher with small diameter stalks, Fig. 4. Analysis of the IB profile based on the nature of destruction of the IB specimens (Fig. 5) shows that the most destructed portion was inside the kenaf stalk, i.e., between the core and bark, and which increased in the order of increasing stalk diameter (S<M<L). This is simply because this part is not applied with adhesive, is soft in nature, and therefore, just crack upon compression. This explains the very low values obtained.

Figs. 6(a) and 6(b) show the WA and TS values, respectively, of the boards. The high values indicate free movement of water inside kenaf stalk. WA tended to increase with increasing diameter of stalk while TS was opposite. This trend may be due to the less substance available to swell in large diameter stalks. While the strength of the boards may indicate sufficiency for use in non-load bearing applications (e.g. for ceiling) in building and houses, the boards very high WA and TS values preclude use in humid conditions.

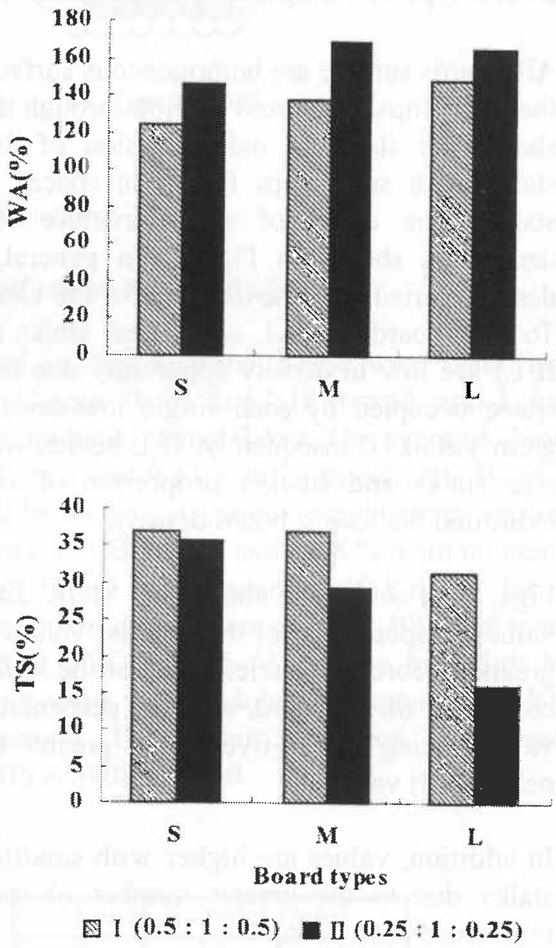

Figure 6 WA and TS of Type 1 boards

Boards type 2 : Three-layer composite board using kenaf stalks

Although the surface layer of the boards was also of kenaf stalks, the bord surface was flat, smooth, and brown as a result of sufficient pressing, apparently irrespective of press temperature. Fig. 7 shows that varying the pressing temperature did not affect board density.

In Fig. 8(a), an increase in temperature caused only slight decrease in MOR values in the ⊥

but in the ∥ orientation of the surface stalks. At any temperature, there was no big difference in values between the ⊥ and ∥ orientations. This may due to the interesting structure of the boards. The surface and core layers take alternative positions according to the orientation of test.

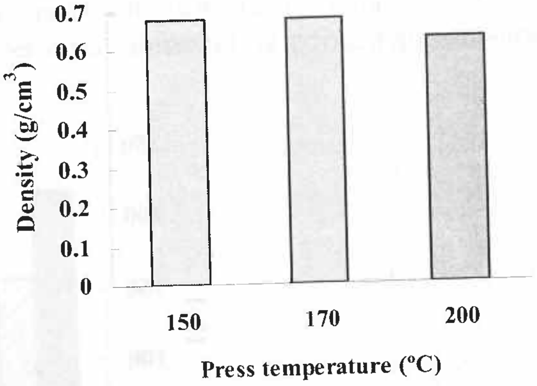

Figure 7 Density of Type 2 boards

In the case of MOE Figure 8(b), however, a big difference was observed between the ⊥ and ∥ values. The higher value in the ⊥ direction is attributed to the resistance of the fibers in the bonded surface kenaf stalks; whereas in the ∥ direction, the fibers pose little resistance to loading.

Figure 9 shows the IB strength of the boards. The values, particularly of boards pressed at 200 °C are little higher than those of the type 1 boards. It was observed that with boards pressed at 150 °C and 170 °C, the compressed stalks tended to spring back after the release of pressure. This tendency was less or absent with boards pressed at 200 °C, indicating better bonding of the stalks togetherand irreversible collapse of the core of the stalks.

The boards also exhibited better dimensional stability with higher pressing temperature. Figure 10 shows the WA and TS values decreasing with higher pressing temperature. Nevertheless, the values are higher than those of the Type 1 boards.

Due to the structure of this type of the board, the strength properties are generally higher than those of the Type 1 boards. The poorer dimensional stability, on the other hand, may be due to the greater number of the stalks whose soft core could easily absorb water and

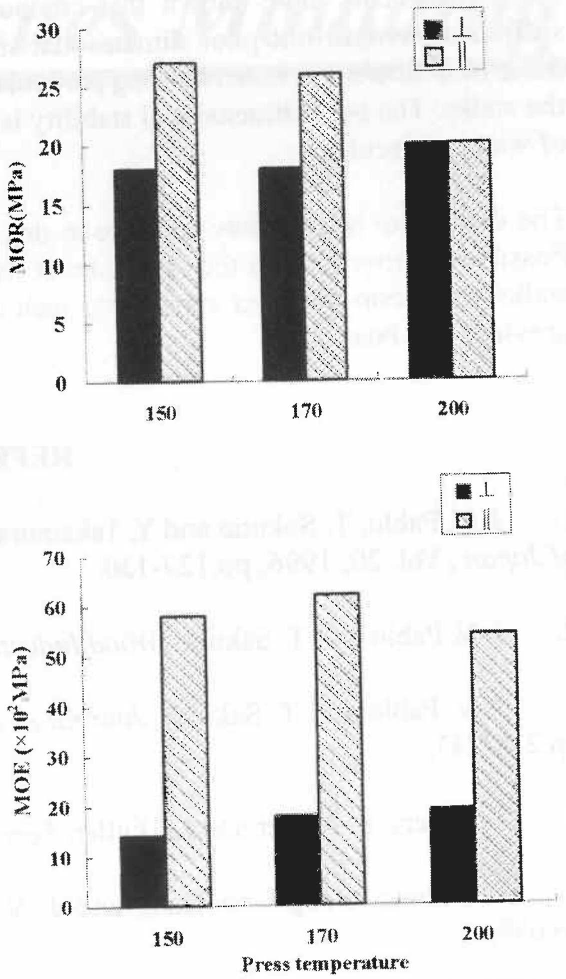

Figure 8 (a) MOR and (b) MOE of Type 2 boards

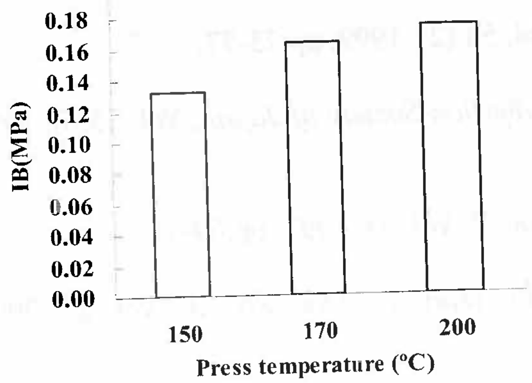

Figure 9 IB of Type 2 boards

swell back upon immersion in water. Thus, use of the boards may also be limited to non-loading bearing and interior purposes.

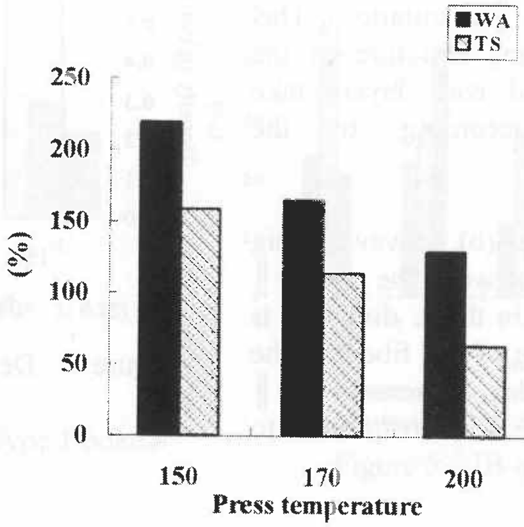

Figure 10 WA and TS of Type 2 boards

CONCLUSIONS AND RECOMMENDATIONS

The experiments have shown that composite boards from kenaf stalks yield boards with sufficient strength but poor dimensional stability. The strength is attributed to the bark and inner bark fibers that resist loading particularly when tested in the perpendicular orientation of the stalks. The poor dimensional stability is due to the soft core where there is free movement of water molecules.

The composite boards may find use in dry, interior applications in the buildings and houses. Possible improvement in the dimensional stability may be achieved by pre-impregnationof the stalks with resin or water repellants, such as polyethylene glycol or wax emulsion, prior to pressing into boards.

REFERENCES

1. J. V. Pablo, T. Sakuno and Y. Takamura, *Transsactions of the Materials Research Society of Japan* , Vol. 20, 1996, pp.127-130.

2. J. V. Pablo and T. Sakuno, *Wood Industry*, Vol. 54 (2), 1999, pp.73-77.

3. J. V. Pablo and T. Sakuno, *Journal of the Adhesion Society of Japan*, Vol. 35(6), 1999, pp.239-247.

4. T. Sellers, G. Miller and M. Fuller, *Forest Prod. J*, Vol. 43, 1993, pp.69-71.

5. T. Sakuno, Seog-Goo Kang and J. V. Pablo, *Transact. Mat. Rec. J.*, Vol. 25, 2000, pp.689.

6. A. Grigoriou, C. Passialis and E. Voulgaridis, *Holz als Roh und Werkstoff*, Vol. 58(5), 2000, pp.309-314.