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# Production and Properties of Boards Made from Kenaf and Sugi Chips Mixture

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Particleboards were manufactured using chips made from kenaf (*Hibicus cannabinus* L.) and sugi (*Cryptomeria japonica* D. Don) thinnings mixed at various weight ratios bonded with phenol formaldehyde (PF), melamine-urea formaldehyde (MUF) and isocyanate (IC) resin adhesives. The bending (MOR) and internal bond (IB) strengths and dimensional stability properties of the boards were measured and evaluated. Bending strength test results showed a decreasing trend as the ratio of kenaf is increased with no significant difference according to the adhesive. As to IB, for the dry condition, IC boards gave the highest values while MUF and PF showed similar trends. Almost no difference was seen according to the ratio of kenaf and sugi, and boards made with pure kenaf showed enough IB strength. For the wet condition, the same trend was shown but boards using pure kenaf had low values. Regarding dimensional stability (water absorption: WA, thickness swelling: TS), IC boards had the lowest values, next is MUF and PF the highest, indicating poor dimensional stability. As the ratio of kenaf was increased, a slightly increasing trend in WA and TS was observed.

Key words: kenaf, sugi, mixing ratio, board production, properties

## 1. INTRODUCTION

The present demand for wood-based board 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 resources, the fear of shortage due to the logging ban and export restriction in many countries led to the search for alternative resources. Among these, application researches on non-wood agricultural resources are being done vigorously. Studies on the manufacture of boards using sugar cane rind etc. have been conducted and reported by the authors[1-3].

Kenaf (*Hibicus cannabinus* L.), a non-wood agricultural resource has recently been the target of attention and researches on its practical use is being conducted in different fields. A fast-growing year-round grass, kenaf's fibers are being used as raw material for papermaking, etc. Its core has been investigated as a possible construction material but more studies on its efficient use are being sought for. Thus in this paper, boards were made using kenaf core and its properties were examined. Kenaf is a light and soft raw material and its use in combination with sugi chips for board manufacture was attempted. To date, many investigations on the effective utilization of sugi small diameter thinnings have been done but its conversion into chips and use as board production raw material is another likely method.

## 2. MATERIALS AND METHODS

### 2.1 Materials

Tottori-grown kenaf stalks were dried and then the core was turned into chips using a chipper. For this, chips passing 11.5 mm mesh with an average density of 0.14 g/cm$^3$ were used. On the other hand, sugi thinnings were planned to obtain chips (10 x 30 mm, 0.1-0.2 mm thickness, 0.33 g/cm$^3$ density).

These chips were dried to 2-4 % moisture content and used for board production. The binders used were three kinds of commercial adhesives (Oshika Shinko) namely melamine-urea formaldehyde (MUF), phenol formaldehyde (PF) and isocyanate (IC) resin.

## 2.2 Methods

Boards using both kenaf and sugi chips mixed at weight ratios of 70:30, 50:50 and 30:70, and boards using 100 % of either chips were manufactured. The adhesives were added at 10 % of the chip weight for MUF and PF, and 8 % for IC. Now, the amount of curing agent added was based on the adhesive manufacturer's specifications. For MUF, wax was added at 5 % solids content weight.

Thickness bar was used to obtain a board with dimensions of 200 x 200 mm, 10 mm thickness. The amount of chips was controlled to achieve the target density of 0.65 g/cm$^3$. Press conditions (temperature, pressure, time) were at 170℃ for MUF and IC, 180℃ for PF at 40 kgf/cm$^2$ for 4 min then at 30 kgf/cm$^2$ for 2 min. The manufactured boards were conditioned for 1 week after which the bending strength (MOR), internal bond (IB), water absorption (WA) and thickness swelling (TS) were measured following JIS A 5908 method.

# 3. RESULTS AND DISCUSSION

## 3.1 Board appearance

The surface appearance of boards made with 100 % of either kenaf or sugi chips were quite different. That is, since kenaf chips are white, the kenaf boards appear whitish. On the other hand, in the sugi boards, since the sugi chip consists of both heartwood and sapwood, boards made mostly of heartwood chips and sapwood chips are brownish and pale white in color respectively. Due to this, in boards made with both chips, the more kenaf there is, the white kenaf is conspicuous; the less kenaf there is, its presence becomes less striking. Such surface pattern created by the mixture of brown and white chips gives the board one big unique quality. PF-bonded boards are rather brownish but there was almost no difference in the surface condition according to the kind of adhesive used.

Regarding density, the target density was at 0.65 g/cm$^3$ but variations within 0.58 - 0.72 g/cm$^3$ resulted. This is because the density distribution within the board slightly varies with the kind of adhesive used and also due to the density difference of the boards made with 100 % of either kenaf or sugi chips.

## 3.2 Strength properties

Fig. 1. shows the boards' bending strengths. Boards made with 100 % sugi chips, regardless of the kind of adhesive used, showed considerably higher bending strength than the other boards. For the other cases, as the ratio of kenaf increases, the MOR decreases slightly and the 100 % kenaf boards gave the lowest values. The density of kenaf chips is low and to reach the target board density of 0.65 g/cm$^3$, the compaction ratio was increased and yet a value lower than this was obtained. This could be the reason for the decrease in bending strength. In general, PF boards had comparatively high values.

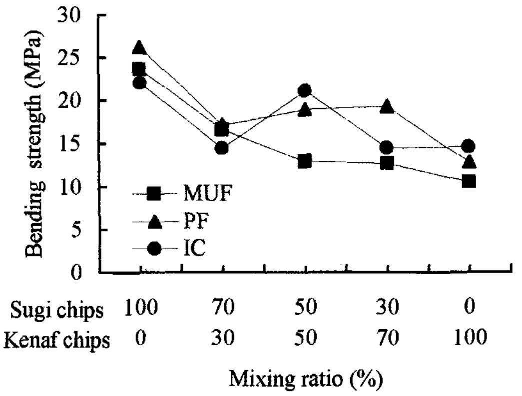

Fig. 1. Effect of mixing ratio on the bending strength of boards.

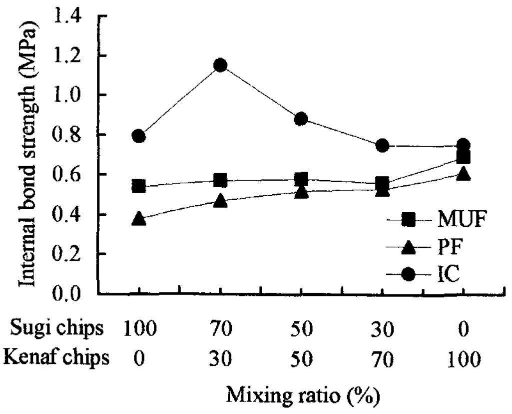

Fig. 2. Effect of mixing ratio on the internal bond strength of boards tested under normal conditions.

Fig. 2 shows the boards' IB strengths at normal condition. For each kind of adhesive, the trend according to the mixing ratio was largely different. That is, the IB strength of IC boards was comparatively higher and different values were observed based on the mixing ratio.

On the other hand, in PF boards, extremely low values were obtained for all mixing ratios. In MUF and PF boards, as the ratio of kenaf becomes larger, a trend of somewhat increasing IB strength was observed. This is because the more kenaf there is, the compaction ratio also increases improving the contact between the chips and thus increasing the IB strength. Generally, IC is superior as a high contact adhesive and is considered to increase the IB strength but its relation to chip mixing ratio and the reason for the resulting trend is unknown.

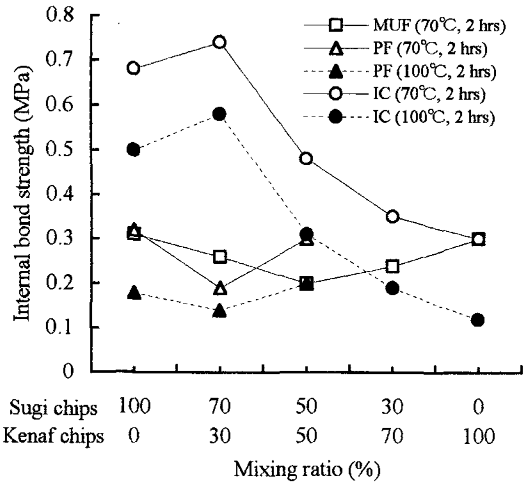

Fig. 3. Effect of mixing ratio on the internal bond strength of boards tested under wet conditions.

Fig. 3. shows the IB strengths of boards soaked for 2 hours in 70℃ and 100℃ water. All mixing ratios of the MUF boards soaked in 70℃ water retained 50-60% of their normal condition IB values. For PF boards, 100 % sugi boards had almost the same value as that of the normal condition. In boards with kenaf chips at 70 % and above, delamination occurred, which made the measurement of IB strength impossible. For the IC boards, the IB strength decreased compared with the normal condition but with regards to the mixing ratio of kenaf, almost the same trend as the normal condition was observed wherein the highest value was at 30 % mixing ratio. It is also clear that a high value was retained than the other adhesives. In the case of specimens soaked at 100 ℃, all MUF boards delaminated, which made IB strength measurement impossible. The delamination of PF boards with kenaf chips at 70 % and above was also observed. A possible reason for the low water durability of the PF boards is the non-addition of wax. On the other hand, for the IC boards, the IB strength decreased considerably but the bonding strength was retained for all mixing ratios exhibiting superior water durability. It is thought that the decrease in bonding strength with an increase in the mixing ratio of kenaf is due to its large water absorption property.

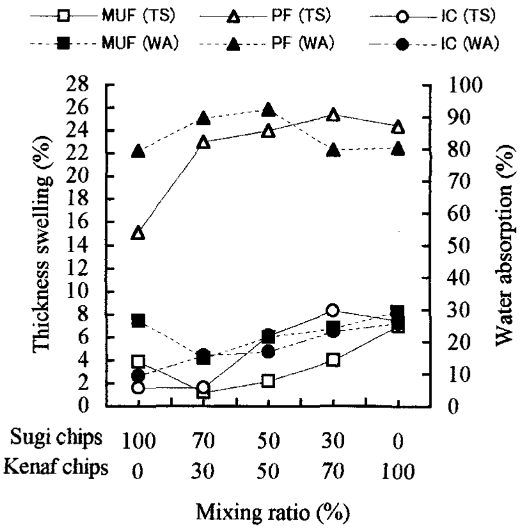

Fig. 4. Effect of mixing ratio on the thickness swelling (TS) and water absorption (WA) of boards (25℃, 2 hrs).

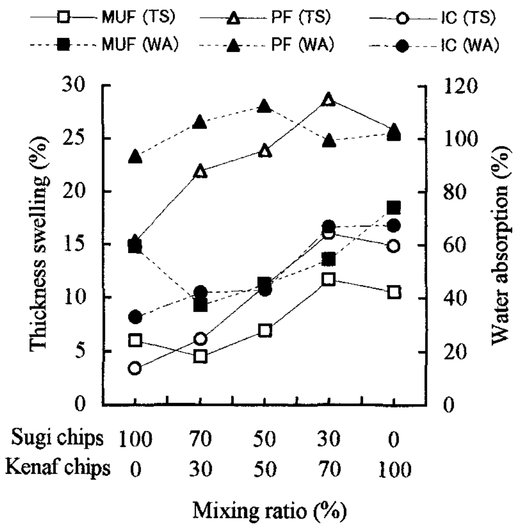

Fig. 5. Effect of mixing ratio on the thickness swelling (TS) and water absorption (WA) of boards (25℃, 24 hrs).

### 3.3 Dimensional stability properties

The water absorption and thickness swelling of boards soaked in 25℃ water for 2 and 24 hours respectively, are shown in Figs. 4 and 5. In both cases, a trend of increasing water absorption and thickness swelling with the increase in kenaf mixing ratio was observed. PF boards in all mixing ratios had extremely high WA and TS values compared to the other adhesives. This is due maybe to the non-addition of wax as earlier mentioned. But in general, PF has comparatively superior water durability and the above result can be due to other causes. The WA and TS values of MUF boards soaked for 24 hours were low and indicated superior water durability. Moreover, the large water absorption property of kenaf in comparison to sugi caused a rise in the WA and TS values showing the decrease of the water durability property. Thus considering dimensional stability, it is evident that kenaf must not be mixed at large proportions.

## 4. CONCLUSIONS

(1) Boards manufactured from kenaf and sugi chips combined at various mixing ratios using MUF, PF and IC as binders had satisfactory appearances.

(2) 100 % sugi boards exhibited the highest bending strength value and as the ratio of kenaf increases, a trend of decreasing MOR was observed. Difference according to the kind of adhesive was not seen.

(3) For normal IB strength, the order is IC>MUF>PF wherein IC boards gave particularly high values. For MUF and PF boards, the value increased with increasing kenaf mixing ratio. For wet IB strength, an increase in kenaf mixture caused the value to decrease in IC boards. An extremely high IB strength was retained by the MUF boards at 70℃.

(4) A trend of increasing WA and TS value with increasing kenaf mixing ratio was observed. The WA and TS values of PF boards were particularly high indicating inferior water durability. This was thought to be due to the non-addition of wax.

## REFERENCES

1) J. V. Pablo, T. Sakuno, and Y. Takamura, *Transactions of the Materials Research Society of Japan*, **20**, 127-130 (1996).

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

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

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