

Properties of Bentwood for Esthetic Designing by Microwave and Ammonia Solution Treatment

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ABSTRACT

This study was carried out to know bending process property of bentwood by treatment methods such as microwave and ammonia solution treatment. Bentwood processing was operated on bending-jig form with 60mm and 100mm radius of curvature (ROC). The species was used to Korean red pine (*Pinus densiflora*). No significant difference was shown in bentwood processing method on ROC. In treatment method, ammonia solution treatment for bentwood was better in dimensional stability and working ability than that of microwave treatment. However, bentwood stress was reduced with ammonia solution treatment. Color of bentwood surface appearance has a dark tendency in ammonia solution treatment. But it seems to beautiful effect of apparent annual ring is rising esthetically by ammonia solution treatment. To utilize wood as a exterior material for living amenity, it has to be closely examined from various angles including surface property, degree of swelling and shrinkage, drying state, retaining strength, durability, safety, and insect damage.

Key words: Bentwood, Microwave and ammonia solution treatment, Exterior material, Amenity.

INTRODUCTION

In the middle of the 19th century, Michael Thonet found that an effective technique for wood bending based on steam pre-treatment. This technique was introduced to many countries upto now all over the world for beautiful curve line of bentwood and it is still widely used to obtain various curved parts of furnitures, architecture, exterior wood for landscape view, musical instruments, barrels, interior decorations and etc.

When a wood is bent, the convex side of the bend is compressed. The wood piece softened by steaming can be compressed considerably (Dwianto 2000). But wood cannot be elongate very little. It is well known that the bending quality of wood varies widely among the different species and also within the same species (Kang 2001; Jung 2001; Jung 2002).

Generally, bending method for bentwood and dimensional stability is very important issues to now, because of its elasticity for recovery (Hsu 1988). PEG treatment effect in greenwood better than drying condition, also its energy consumption appeared low value (Kwon 2002). Urethane varnish coating has intercept to moisture and clarity, also urethane varnish coating woods has polishing property (Lee 1995).

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On the use of exterior wood, first, the characteristics of wood have to be understood. Therefore exterior wood can be used while preserving its safety and beauty over a long time by adequate physical and chemical treatment (Bae 1999). The direction of a durable design for the practical use of exterior wood as landscape materials was examined.

In this study, we have examined that to know the difference of ROC strain between cross sections of bentwood on microwave heating and ammonia solution soaking treatment method. At last, investigation was carried out to examine the using point of wood materials involved in bentwood as a landscape material.

MATERIALS AND METHODS

Material

The specimens were collected from the study forest of Kyungpook National University in Chungsoong Province. The species was Korean red pine (*Pinus densiflora* Sieb. et Zucc.). Diameter at the breast height (DBH) was 200mm; tree age was 40 years, moisture contents in air dry condition (MC) was 16. The dimension of specimens was 10 mm (R) by 20 mm (T) by 350 or 400 mm (L). Jigs made of a strap (carbon steel, thickness, t: 0.6 mm) with wood handles at both ends as well as wooden forms were used in the bending operation. Radii of forms (ρ) were 60 mm and 100 mm.

Measurement of ROC (radius of curvature) and end distance

Fig. 1 shows a schematic diagram of the bent specimen. The radius of curvature (ρ) and the compressive strain (ε) on the concave surface of the bent specimen are calculated by following equations. Based on Fig. 1, connected to a straight line AB, ROC (ρ) and end distance strain (φ) measured as follows:

$$\rho = \frac{a^2 + b^2}{2b} \text{ -----(1)}$$

$$\delta = \frac{|\rho - \rho'|}{\rho} \times 100 \text{ -----(2)}$$

$$\phi = \frac{(\varphi - C'D')}{\varphi} \times 100 \text{ -----(3)}$$

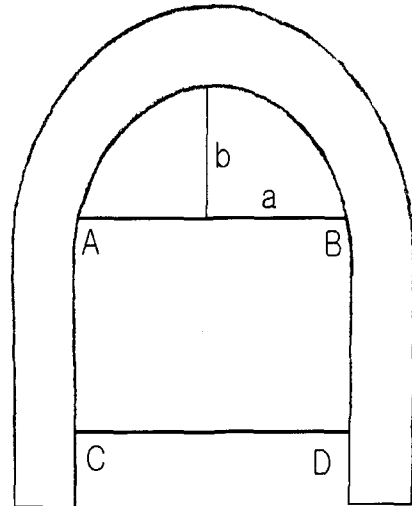


Fig.1. Diagram for strain measurement.

AB: original length, CD: original end distance, C' D': end distance after one-week, ρ: ROC after one-week, δ: strain of ROC, φ: strain of end distance.

Microwave heating and ammonia treatment

Test specimen was sealed tightly with vinyl lapping and heated for 90 seconds by microwave (fr= 2,450MHz, 700W). The other test specimens were soaked in liquid ammonia solution (28% concentration) for 24 hours.

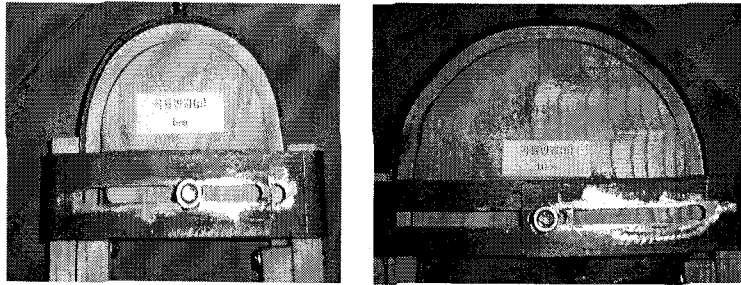


Fig.2. Apparatus of bending jig (left: 60mm ROC, right: 100mm ROC).

RESULTS AND DISCUSSIONS

Strain of end distance

Figs. 3 and 4 show the strain of end distance of bentwood with time by two soften methods such as microwave heating and ammonia solution treatment. From these figures, the strain of all specimens was increased describing a parabola with time. Increase style of two methods is tendency to very similar. Strain is very large values with time than anything else. Therefore, it is necessary to fixation using any method to reduce of end distance strain on bentwood. In jig form curvature, strain of 100mm ROC was shown more stable relatively than 60 mm ROC. In pre-treatment method, strain was larger on microwave heating treatment. The reason of this phenomenon is considered that ammonia treatment was softening to extremely on lignin and swelling of hydrogen bonding in cell wall and cellulose crystalline. Therefore, wood is shown more effective plasticity (Bariska et al., 1969; Schuerch 1964; Kang 2001). In bending process for bentwood, main strain is considered end distance strain because of this strain of bentwood was very larger than ROC strain.

The merit of microwave heating method is very convenience with short time heat processing and a safe device. But initial equipment cost of microwave device is not small. In contrast, ammonia solution treatment method is low cost, but this method is very dangerous and lower working ability and reduction of bentwood strength. Color of bentwood surface appearance has a dark tendency in ammonia solution treatment. But it seems to beautiful effect of apparent annual ring is rising esthetically by ammonia solution treatment. If the ammonia treatment could be promote in bentwood working ability, this bentwood will be used as many useful materials such as furniture members, architecture members, exterior wood in landscape design, and so on.

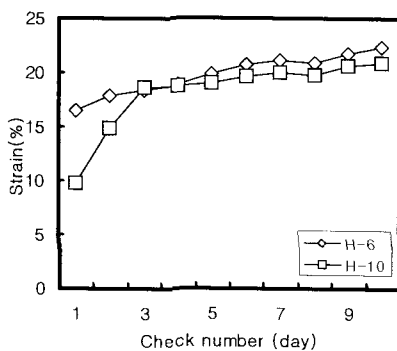


Fig.3. End-distance stain by microwave heating. Legend: 6cm (up), 10cm (down) ROC.

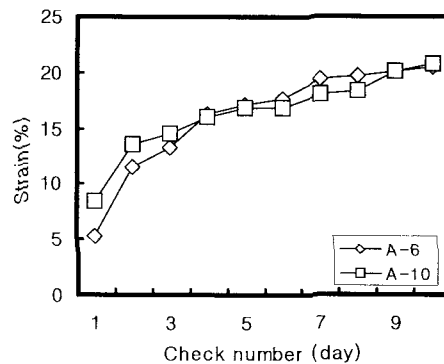


Fig.4. End-distance strain by liquid ammonia treatment. Legend: 6cm (up), 10cm (down) ROC.

Strain of ROC

Figs. 5 and 6 show the strain of ROC of bentwood with time by two soften methods such as microwave heating and ammonia solution treatment. ROC strain is small values than strain of end distance. In this case, the strain is increased with time on two softening methods. Strain in 100 mm ROC is higher than 60 mm ROC. And also ROC strain by microwave heating is over twice than ROC strain by liquid ammonia treatment. Though ROC and end distance were increased until 9 days, it is considered that this tendency to more increased with time.

We thought that the reason of this phenomenon due to changed moisture content and residual stress during bent. Specially, strains of end distance by bending treatment were indicated to high value than ROC strain. Therefore, it is necessary to strain fixation on strain of end distance during bentwood using.

Figs. 7 and 8 illustrate the appearance of bentwood surfaces as liquid ammonia treatment method and microwave heating treatment. Color of bentwood surface appearance has a dark tendency in ammonia solution treatment. But it seems to beautiful effect of apparent annual ring is rising esthetically by ammonia solution treatment.

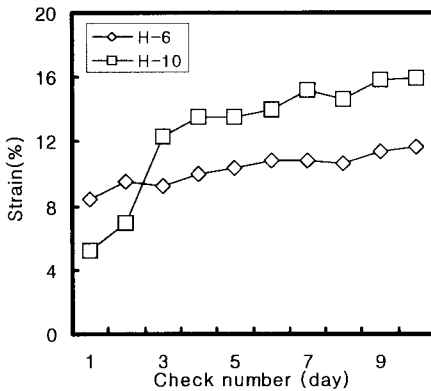


Fig.5. ROC strain by microwave heating. Legend: 6cm(up), 10cm (down) ROC.

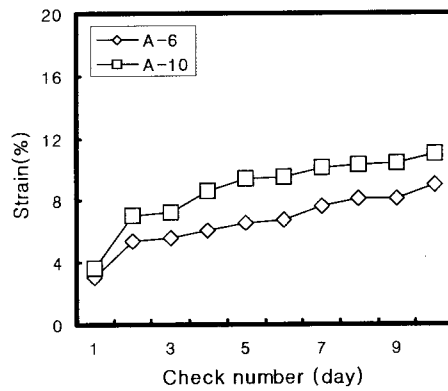


Fig.6. ROC strain by liquid ammonia treatment. Legend: 6cm (up), 10cm (down) ROC.

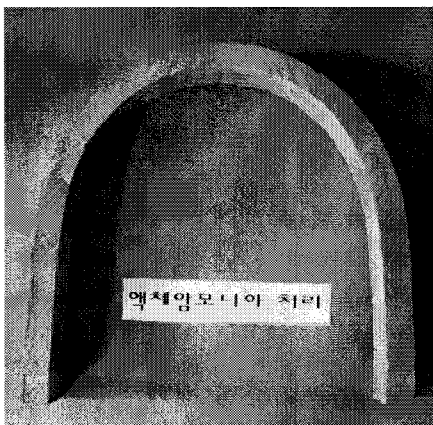


Fig.7. Ammonia solution treatment for bentwood.



Fig.8. Microwave heating treatment for bentwood.

Utilization of exterior wood

It was examined that wood is used as an object of outdoors facilities. An investigation of utilization type of wood was carried out and divided into: 1. a use range, 2. a use type, 3. a processing method by the conferences and case investigations.

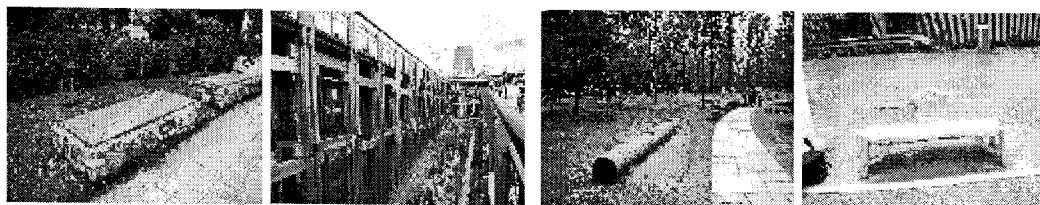
1. Utilization of exterior wood by a use range

In this section, exterior wood was classified as material used in outdoors facilities. In this case, the investigation was carried out into two categories, 1) whole utilization and 2) in partial utilization (Table 1 and Fig.9).

2. Utilization of exterior wood by a use type

Table 1. Use range of wood by outdoor facilities

Wood Facilities	Use range		Wood Facilities	Use range	
	Whole	Part		Whole	Part
Bench	●	●	Boundary	●	●
Wastebasket	●	●	Sound isolation wall	●	●
Signboard	●	●	Bridge	●	●
Kiosk		●	Stairway	●	●
Shelter		●	Pergola	●	●
Illumination lamp		●	Outdoors table	●	●
Boundary stone	●	●	Pavilion	●	●
Tree supporter	●	●	Walking road	●	●
Planter	●	●	Play facilities	●	●
Parking area	●	●	Hydroponics facilities		●
Overbridge		●	Inclined plane		●
Fence	●	●			



a. Partial wood utilization

b. Whole wood utilization

Fig. 9. Classification of use range (a,b).

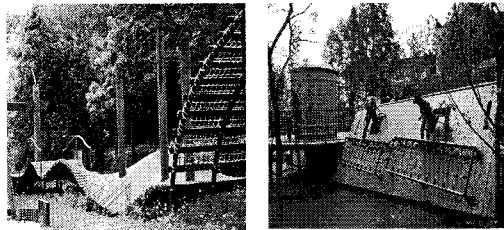
In this section, exterior wood was classified as material used in outdoors facilities. In this case, the investigation carried out uncovered three categories of use types such as utilization of log or wooden board and a square lumber or laminated lumber (Fig 10).

3. Utilization of exterior wood by a wood processing method

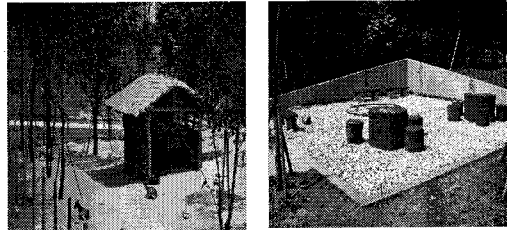
In the case of wood used in facilities materials, an investigation was carried out into three categories, 1) by treatment method such as non-processing wood, 2) preservation treatment against decay, and 3) heat treatment processing or a coating processing (Fig 11).

Conditions of exterior wood as a landscape material

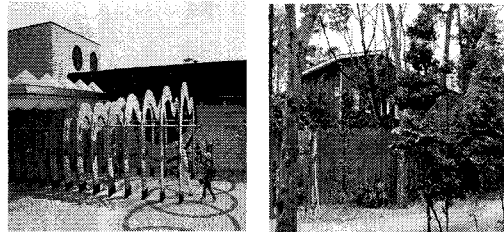
To have a good application of wood, we have to examine whether wood characteristics and materials used in the outdoors and public facilities can satisfy criteria for landscape materials. A required condition as landscape materials will be different from a kind of facilities, construction place, and utilization type (use range, use type, processing method) (Bae et al. 1999). It was examined an applicable range and direction and the point of exterior wood at outer space based on wood property.



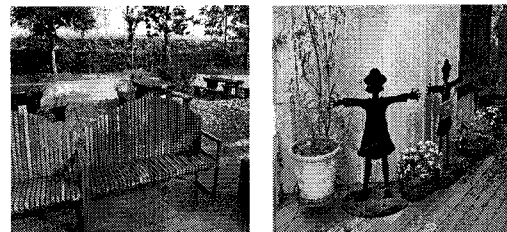
a. Play facilities using log b. Play facilities using square lumber



a. Use of raw wood b. Preservation treatment log



c. Fence using wooden board d. Laminated lumber
Fig.10. Case classification by use type of exterior wood.



c. Finish by heat treatment d. Finish by painting
Fig.11. Case classification by wood processing method.

Necessary condition for exterior wood

Wood is a natural material which easily decays. The degree of decay varies with the processing degree and circumference environment and construction location when using wood in outdoor facilities (Haygreen and Bowyer 1982). For these reasons, a sustainable new technology of wood facilities is a very important issue (Barnes and Kim 1993). For instance, if wood material is rotting away and damaged by insect or fungi, wood facilities will be faced with dangerous conditions such as a reduction in strength, serious safety trouble, and aesthetic problems. The most serious problem of wood as a landscape material is the phenomena of degradation. For this reason, rot may cause defects such as aesthetical and structural problems. Furthermore, one of the main defects of wood is easily deformed such as a cleavage, warping with moisture troubles. This deformation appears with time after executing the facility construction. This deformation is connected to the deformation of structure itself. Furthermore, wood is flammable. These specific properties of wood are connected directly with the reduction of safety. It is necessary that public facilities ensure peoples safety.

To utilize wood as a landscape material, it has to be closely examined from various angles including surface property, degree of swelling and shrinkage, drying state, retaining strength, durability, safety, and insect damage.

CONCLUSION

This study thought about effect of dimensional stability for bentwoods following treatment methods and treatment conditions such as microwave and ammonia solution treatment. No significant difference was shown in bentwood processing method on ROC. In treatment method, ammonia solution treatment for bentwood was better in dimensional stability and working ability than that of microwave treatment. Color of bentwood surface appearance has a dark tendency in ammonia solution treatment. But it seems to beautiful effect of apparent annual ring is rising esthetically than that of microwave treatment. To utilize wood in a exterior environment, it has to be closely examined from various angles including surface property, degree of swelling and shrinkage, strength, durability, safety, and insect damage.

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