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Characteristics of the Radio-Frequency/ Vacuum Drying of Heavy Timbers for Post and Beam of Korean Style Housings Part I*1: For Japanese larch round logs with 150 mm and 210 mm in diameter and 2,500 mm in length

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ABSTRACT

The characteristics of radio-frequency/vacuum drying Japanese larch boxed heart round logs with 150 mm and 210 mm in diameter and 2,500 mm in length, subjected to compressive loading, after the pretreatment of kerf were investigated. The results of this study were as the follows: The drying time of about 120 hours~130 hours was needed from green to about 15 percent of moisture content. The gradient of final moisture content for all specimens was very gentle in both longitudinal and transverse directions owing to dielectric heating. The surface checks seriously occurred although the occurrence extent of surface check for the kerfed specimens was slight compared with that for the control specimens because drying stress was relieved by kerf. The occurrence of surface checks for the L-specimen was more serious than that for the S-specimen.

Keywords : Boxed heart round logs, Kerf treatment, Radio-frequency/vacuum drying, Surface check

1. INTRODUCTION

The importance of wood as a building material and a renewable resource was increasing due to the growing concern of human health and well-being housing environment. Consequently, the gross wooden building area in Korea had largely increased in years past. The result of a recent investigation showed that both suppliers and users of wooden houses preferred the wooden house constructed traditionally with the post-beams with very large cross section, which

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were desired to be exposed to eyes, to shinbone constructed wooden houses in Korea. Owing to the revised construction law of Korea, the maximum height of roof and eaves reaches to 18 m and 15 m, respectively. Therefore, the need for the long structural timbers with large cross section was expected gradually increasing.

However, the severe surface checks often occurred on the pillar with large cross section during drying and, moreover, long drying period was required because of the pillar containing juvenile wood and pith, and long moisture flowing distance from core to moisture evaporating surfaces. These not only incurred spoil of the beauty, fall in durability and insulation, crack of a copula and loss of strength but also were a main cause to force up the cost of wooden houses.

Some researches (Graham, 1973, 1979; Helsing and Graham, 1976; Evans *et al*., 1997, 2000) to minimize sever check formation were conducted. An effective technique was kerfing. Kerfing is the technique whereby a saw cut, extending to the pith, was made longitudinally along a pole. However, all these studies were performed on round wood under conventional or air drying condition.

When Radio-Frequency/Vacuum (RF/V) drying was applied to the pillar with large cross section, it was found out not only that drying time could be shortened, because a driving power to accelerate the flowing rate of the moisture in wood was actively displayed since a difference in the absolute pressure between the shell and core of wood was formed due to dielectric heating, but also that several problems being accompanied with the process of drying were partly resolved. Nevertheless, it was also reported that RF/V drying had a limitation of perfect preventing the surface checks from the long pillars with large cross section (Harris, 1984; Kanagawa, 1989; Avramidis *et al*., 1994; Lee and Luo, 2002).

Although the pretreatment of high temperature with low humidity was effective in preventing surface checks, internal checks occurred when high temperature drying was operated, and too long drying period required when air drying was carried out (Yoshida *et al*., 2000). Hence, it was expected that the desired effects such as effective prevention of both surface and internal checks, shortened drying period, and theeven distribution of moisture content (MC) in each pillar could be achieved.

Some fundamental researches on the drying characteristics of the small size of wood subjected to compressive loading during RF/V drying have been conducted in order to solve the problems mentioned above (Lee *et al*., 2004; Kang *et al*., 2004; and Li and Lee, 2004, 2008). However, the research on the RF/V drying characteristics of the heavy timber is still few.

A series of studies, consisted of 2 parts, on the RF/V drying characteristics of the heavy logs with different cross section and length after the pretreatment of kerf was conducted.

This study aims to clarify the characteristics of RF/V drying Japanese larch boxed heart round logs with 150 mm and 210 mm in diameter and 2,500 mm in length, subjected to compressive loading, after the pretreatment of kerf.

2. MATERIALS and PROCEDURES

2.1. Preparation of Specimens

Twenty seven Japanese larch (*Larix leptolepis G.*) boxed heart round logs with 150 mm (S) and 210 mm (L) in diameter, and a fixed length of 2,500 mm were prepared in this experiment. The S-specimens and L-specimens were divided into control and kerfing treatment specimens, respectively. The dimension, quantity and initial moisture content of specimens are given in Table 1.

Table 1. The dimension, quantity and initial moisture contents of specimens

Wood assortment	Treatment	Diameter × Length (mm)	Quantity (piece)	Initial moisture content (%)
S-specimen	Control	150 × 2,500	6	23.9
	Kerfed		6	27.6
L-specimen	Control	210 × 2,500	7	27.3
	Kerfed		8	30.9

Table 2. Drying schedule

Drying time (hour)	0～72	72～96	96～120	120～192
Wood temperature (°C)	45	50	55	60

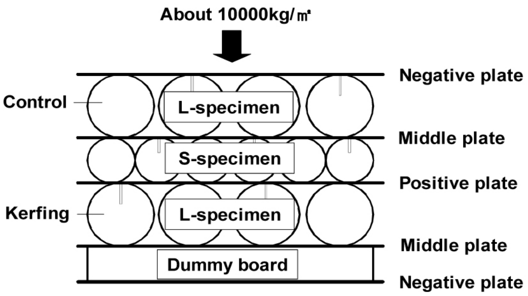

Fig. 1. Stacking diagram of specimens in the RF/V dryer.

2.2. Kerfing Treatment

The longitudinal kerfs with a width of 3 mm and the depth of one third of the diameters, 50 mm from the circumference of the S-specimen and 70 mm from that of the L-specimen, were sawn with a circular saw.

2.3. Radio-Frequency/Vacuum Dryer

The internal dimension of the rectangular chamber of a RF/V dryer used in this study were 600 cm in length, 120 cm in width, and 67 cm in depth. The maximum output of its radio-frequency (RF) generator at a fixed frequency of about 13 MHz, which was turned on for 8 minutes and then off for 2 minutes, was 25 kW. The specimens stacked in the chamber, covering with a flexible rubber sheet, were compressively loaded by the pressure of 10,000 kgf/m^2 during drying.

2.4. Stacking of Specimens

The L-specimens were stacked in two layers underneath the central positive plate and the top negative plate while the S-specimens were stacked between the central and middle positive plates. The remainder of the space inside the chamber was filled with dummy boards (Fig. 1). Especially, for the kerfed specimens, the direction in the depth of kerf was paralleled to the direction of the compressive pressure in order to restrain the widening of kerf during drying as much as possible.

2.5. RF/V Drying Schedule

The drying condition in this experiment is shown in Table 2. The ambient vapor pressure was kept at an absolute value of 50 mmHg～70 mmHg. The wood temperature was controlled by a teflon-sheathed platinum 100 Ω sensor with a diameter of 3.5 mm, inserting into a

Fig. 2. The circumferential slices cut from log cross section to survey a distribution of the final moisture content in the radial direction of L-specimens.

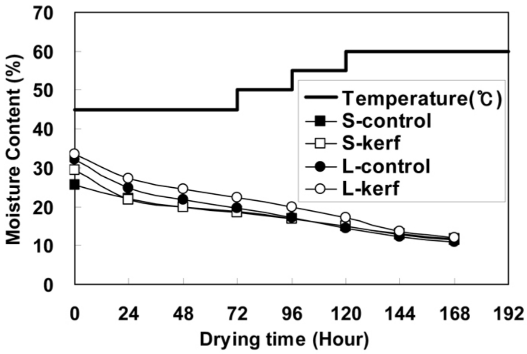

Fig. 3. Drying curves of the moisture content of specimens during RF/V drying.

L-specimen stacked in the upper part of the chamber.

2.6. Drying Curve and Drying Rate

One piece of specimen was selected from the control and kerfed specimens, respectively, to investigate the moisture contents of the specimens during drying. The moisture content and drying rate during drying were obtained from the weight measured at an appropriate time intervals after the dryer was stopped and the oven-dry weight calculated from the final moisture contents of specimens.

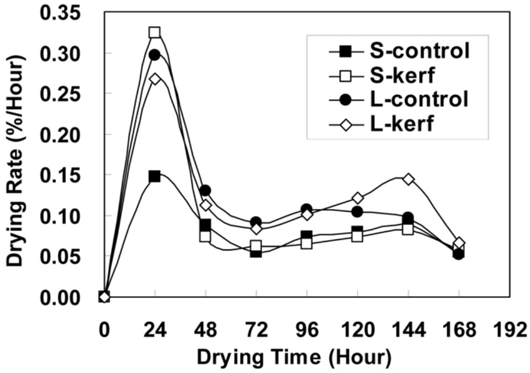

Fig. 4. Drying rate curves of specimens during RF/V drying.

2.7. Distribution of Final Moisture Content

2 cm thick log cross section was sawn off at the positions as far as 41.5 cm, 83 cm, and 124.5 cm, respectively, from one end surface of three control specimens and three kerfed specimens (Fig. 2).

2.8. Shrinkage of Cross Section

The shrinkages of the circumferences of specimens were calculated based on the dimensional changes, measued with π tape, of the circumferences of all specimens before and after drying.

2.9. Surface Check

The total length and numbers of the surface checks occurred on the circumferential surfaces of all specimens were surveyed after drying.

3. RESULTS and DISCUSSIONS

3.1. Drying Curve and Drying Rate

The changes of the moisture content (MC)

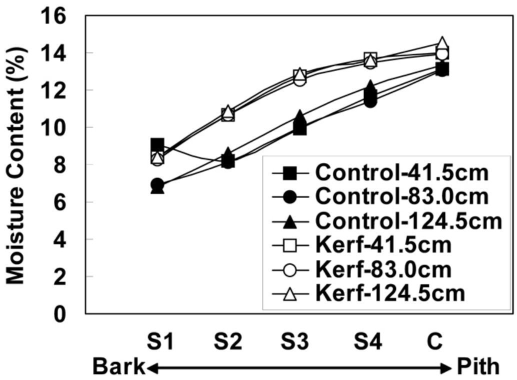

Fig. 5. Distribution in the moisture content of the S-specimens after drying.

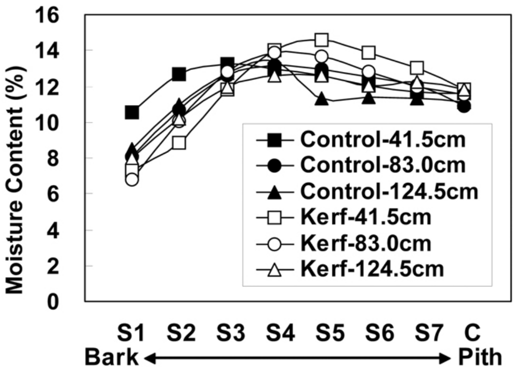

Fig. 6. Distribution in the moisture content of the L-specimens after drying.

Table 3. Shrinkage of cross section of specimens after RF/V drying

Wood assortment	Shrinkage of cross section (%)
S-control	1.94
S-kerfed	1.88
L-control	1.61
L-kerfed	1.56

and drying rate of specimens during RF/V drying are presented in Fig. 3 and Fig. 4, respectively.

The drying time of about 120 hours～130 hours was needed from green to about 15 percent of MC irrespective of wood assortment and treatment, which is very shorter compared to the squared timber studied previously. This could be attributed to the lower initial MC of round logs because moist sapwood had being removed. This explanation was also comfirmated by quite lower drying rate of round logs than that of the squared timber.

On the other hand, the difference in the drying rates between the S-specimen and the L-specimen can be account for the difference in the initial moisture content. This is related to the drying mechanisms that the driving power to accelerate the flowing rate of the moisture in wood is more actively displayed in the range of the high moisture content above the fiber saturation point due to RF/V drying (Yoshida *et al*., 2000).

3.2. Distribution of Final Moisture Content inside Round Timber

The distribution of the moisture contents in the transverse and longitudinal directions of the S-specimens and L-specimens after drying is shown in Fig. 5 and Fig. 6, respectively.

The moisture content inside the S-specimen showed a distribution of higher value from circumferential surface nearer to a centry of specimen irrespective of treatment and distance from the end surface while that inside the L-specimen showed a distribution of higher value of intermediate layer than that of circumferential and central layers. This is due to the type effect of dielectric heating L-specimen in the range of the high moisture content above the fiber saturation point (Kanagawa, 1989; Lee *et al*., 1998).

The moisture contents of both the S-kerfed and L-kerfed specimens presented higher value towards central layer than that of control

Table 4. Occurrence extent of surface check on specimens after RF/V drying

Wood assortment	Average number of the surface checks occurred (piece/piece)	Average length of the surface checks occurred (cm/piece)
S-control	14	162
S-kerfed	14	147
L-control	27	759
L-kerfed	24	460

specimens.

3.3. Shrinkage of Cross Section

The shrinkages of cross section of specimens from green to the end of drying are given in Table 3.

The total shrinkages of cross section for each specimen from green to the end of drying were 1.56 percent～1.94 percent.

3.4. Surface Check

The average total length and numbers of the surface checks occurred on the circumferential surfaces of all specimens after the end of drying are expressed in Table 4.

The surface checks seriously occurred irrespective of wood assortment. The occurrence extent of surface checks for the kerfed specimen was slight compared with that for the control specimen. It was reported (Helsing and Graham, 1976; Lee and Luo, 2002) that the reason for this was that the drying stress was relieved by kerf.

The occurrence of surface checks for the L-specimen was more serious than that for the S-specimen.

4. CONCLUSIONS

The characteristics of RF/V drying Japanese larch boxed heart round logs with 150 mm and 210 mm in diameter and 2,500 mm in length, subjected to compressive loading, after the pretreatmentof kerf can be described as the following:

The drying time of about 120 hours～130 hours was needed from green to about 15 percent of moisture content irrespective of wood assortment and treatment.

The gradient of final moisture content for all specimens was very gentle in both longitudinal and transverse directions owing to dielectric heating.

The surface checks seriously occurred although the occurrence extent of surface check for the kerfed specimens was slight compared with that for the control specimens because drying stress was relieved by kerf.

The occurrence of surface checks for the L-specimen was more serious than that for the S-specimen.

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