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SHORT NOTE

EFFECT OF WIDTH OF ANNUAL RING ON TECHNOLOGICAL PROPERTIES OF PLYWOOD PANELS MANUFACTURED FROM STONE PINE (*PINUS PINEA* L.)

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ABSTRACT

It is known that width of annual ring is the anatomical parameter that affects physical and mechanical properties of wood. Width of annual ring is dispersed homogenously in some tree species, while in some tree species is not. The aim of the study was to determine effect of width of annual ring on some mechanical and physical properties of solid wood and plywood panels manufactured from the same solid wood species having various annual ring widths.

KEYWORDS: Annual ring width, plywood, static bending strength, modulus of elasticity, impact bending strength, shear strength.

INTRODUCTION

It was stated in a study conducted with 12 stone pine wood species which were taken by caring the direction of south – north that when width of annual ring was getting increase, the density of wood was getting decrease. The increasing density from heartwood through the sapwood was also reported (Doğu 1993).

Wood having narrow annual ring had some important properties such as high carrying ability, high resistance (Berkel 1970). Generally, width of annual ring was inversely correlation with density of wood in softwood. Because, while width of annual ring was getting increase, the latewood zone which is heavy portion of wood was getting decrease (Berkel 1970). Adamopoulos et al. found an inverse ratio between ring width and latewood proportion (Adamopoulos et al. 2009). The density of earlywood was lower than those of latewood in stone pine (*Pinus pinea*)

(Kollmann and Côté 1968). Thirteen stone pine trees obtained from 3 different regions in Turkey were investigated in another study. The average width of annual ring, air dry specific gravity, bending strength, compressing strength values of the samples were reported as 4.44 mm, 0.51 g.cm^{-3}, 58.1 N.mm^{-2}, 31.5 N.mm^{-2}, respectively (Erten and Sözen 1997).

MATERIAL AND METHODS

Stone pine (*Pinus pinea* L.), 30 years old, with 35 cm diameter obtained from Trabzon region was used for the study as raw material. Three logs which have more clearly annual ring in hardwood portion were chosen among 50 trees. Logs were cut into a length of 110 cm from chosen logs and then they were divided in parts with a length of 55 cm. Average width of annual ring was measured as 10 mm up to 13 years old and 5 mm from 13 years old to 30 years old in cross section of wood. The parts were divided in two groups. First group was used for veneer manufacturing, while the other group was used for determining of the properties of solid wood. Veneer sheets with 2 mm thick were manufactured by using rotary peeling machine in laboratory condition. While the logs were peeling, acquiring veneers were divided in two groups. First group veneers were manufactured from wood portion with wide width of annual ring, while the second group veneers were manufactured from wood portion with narrow width of annual ring. Both groups were obtained from sapwood sections of woods. Veneers were dried up to 6–8 % moisture content by using a veneer dryer for 5 minutes at 110°C before plywood manufacturing. UF resin was used as adhesive. Approximately 180 g adhesive mixture per square meter was spread on single surfaces of veneers by a four-roller gluing machine. Three-ply, 6 mm thick and 4 replicate plywood panels with dimensions of 55 × 55 cm were manufactured for each group. Hot press pressure, temperature and pressing time were 0.8 N.mm^{-2}, 110°C and 6 minutes, respectively in plywood manufacturing processes. Test samples were conditioned to achieve equilibrium moisture content at 20°C temperature and 65 % relative humidity prior to testing.

RESULTS AND DISCUSSION

It was determined that effect of annual ring width on properties of solid wood and getting results were compared to those of plywood panels. Mechanical properties of panels were evaluated for the general purposes of plywood. Shear strength, bending strength and modulus of elasticity values of plywood panels were determined according to EN 314 and EN 310, respectively. The properties of solid wood were determined according to DIN standards.

The data from each test were statistically analyzed. Two independent samples t-test was used to test (α=0.05) for significant difference among the factors at a 95 % confidence level.

The mechanical properties of solid wood with narrow annual ring were higher than those of solid wood with wide annual ring as shown in Tab. 1 (α <0.05). It was stated that mechanical properties such as modulus of elasticity, bending strength, impact bending of softwood and some hardwood species were getting higher with decreasing the width of annual ring.

It was no clearly difference between density and bending strength of plywood panels manufactured from veneers with wide annual ring and those of plywood panels from veneers with narrow annual ring (α >0.05) (Tab. 2).

The modulus of elasticity and shear strength of plywood panels from veneers with wide annual ring was higher (α <0.05). It was known that latewood zone was getting decrease with

increasing the annual ring width.

It was concluded that width of annual ring did not affect negatively on mechanical properties of plywood panels from veneers with wide annual ring existing in early age of stone pine tree.

Tab. 1: Test results of solid wood samples (n=20).*

Properties	Narrow annual ring (5 mm)		Wide annual ring (10 mm)	
	x	sd**	*x*	sd**
Density (g.cm^{-3}) (DIN 52182)	0.52	0.0128	0.51	0.007
Static bending strength in grain direction (N.mm^{-2}) (DIN 52186)	60.4	6.6	55.9	11.2
Modulus of elasticity in static bending (N.mm^{-2}) (DIN 52186)	6348	993	5886	883
Compression strength in longitudinal direction (N.mm^{-2}) (DIN 52185)	33.5	4.7	31.0	4.6
Impact bending strength (kgm.cm^{-2}) (DIN 52189)	0.35	0.08	0.31	0.06

* : number of samples ** : Standard deviation

Tab. 2: Test results of plywood panels (n=30).*

Properties	Narrow annual ring (5 mm)		Wide annual ring (10 mm)	
	x	sd**	*x*	sd**
Density (g.cm^{-3})	0.53	0.03	0.53	0.02
Static bending strength (N.mm^{-2})	50.1	7.22	50.3	6.99
Modulus of elasticity in static bending (Nmm^{-2})	3266	483	3578	515
Shear strength (N.mm^{-2})	1.37	0.16	1.45	0.12

* : number of samples ** : Standard deviation

As can be seen in Tab. 1, it was found that annual ring width had no influence on density of solid wood samples. It was determined that there was significant difference between the solid wood with wide annual ring and narrow annual ring at a 95 % confidence level accordance to t-test (α>0.05). Lei et al. studied on some technological properties of red alder (*Alnus rubra* Bong.) and found that growth rate had no effect on specific gravity (Lei et al. 1997), while in another study on Norway spruce (*Picea abies* Karst.) it was determined that density had negative correlations to annual ring width (Kubojima et al. 1997). It is known that relation between density and annual ring width has been varied according to wood species (Eraslan 1947; Berkel 1970).

CONCLUSIONS

It was known that mechanical and physical properties of softwood and hardwood species were affected from width of annual ring. In this study, solid wood with narrow annual ring showed better mechanical performance. Density and bending strength of plywood panels were not affected from annual ring width. On the other hand, it was found that the modulus of elasticity and shear strength of plywood panels from veneers with wide annual ring were higher than those of panels from veneers with narrow annual ring.

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