Mugla Journal of Science and Technology

SUITABILITY OF POPLAR AND BEECH LAMINAS FOR LAMINATED VENEER LUMBER MANUFACTURİNG USING MELAMINE FORMALDEHYDE ADHESIVE

İlkay ATAR[1], İbrahim Halil BAŞBOĞA[1], Kadir KARAKUŞ[1], Fatih MENGELOĞLU[1]*

[1]Forest Product Engineering/Faculty of Forestry, Kahramanmaras Sutcu Imam University, 46100, Kahramanmaraş, TURKEY
iatar@ksu.edu.tr, ihbasboga@ksu.edu.tr, karakus@ksu.edu.tr, fmengelo@ksu.edu.tr

Received: 31.10.2016, Accepted: 05.12.2016
*Corresponding author

Abstract

Laminated Veneer Lumber (LVL) has been proven their usefulness and efficiency as framing members (girders, beams, joist, headers, panels, etc.)in construction. Their application and manufacture is limited in Turkey. In this study, four different types of 7-layers LVLs were successfully manufactured using sawed beech (B) and poplar (P) veneers, and melamine formaldehyde (MF) adhesive. In this work, LVLs were formed with two veneers for each surface and three veneers for core layer. Produced four different types of LVL were coded based on the type and location of the veneers. BBBBBBB, BBPPPBB, PPPPPPP and PPBBBPP were called as Group I, Group II, Group III and Group IV, respectively. As physical properties, oven dry specific gravity (SG) and moisture content (MC) were determined according to TS 2472 (1976a) and TS 2471 (1976b) standards. Mechanical properties like glueline shear strength, modulus of rupture (MOR), modulus of elasticity (MOE) and compression strength (CS)(parallel to grain) were also determined according to EN 314-1 (2004),EN310 (1993) and TS 2595 (Anonymous 1977)standards, respectively. Based on this study, the highest strength and SG values were obtained with all beech used veneers (Group I). On the other hand lowest values were recorded with all poplar veneers (Group III). It should be noted that contribution rate of beech veneers in LVL had an increase on both strength and SG values.
Keywords: Laminated veneer lumber (LVL), Melamine Formaldehyde, Poplar, Beech, Modulus of elasticity, Glue

KAYIN VE KAVAK KAPLAMALARIN MELAMİN FORMALDEHİT TUTKALI KULLANILARAK LAMİNE KAPLAMA KERESTE ÜRETİMİNE UYGUNLUĞU

Özet

Lamine kaplama kereste (LVL) inşaat yapılarında kiriş, döşeme kirişi, başlıklar ve paneller gibi çerçeve üyeleri olarak etkili ve kullanışlı olduğunu ispatlamıştır. LVL'nin Türkiye'de uygulaması ve üretimi sınırlıdır. Bu çalışmada biçilmiş kayın ve kavak kaplamaları, melamin formaldehit (MF) tutkalı kullanılarak dört farklı tipte yedi tabakalı LVL'ler üretilmiştir. LVL'ler her dış tabaka için iki adet kaplama ve iç tabaka için üç adet kaplama olacak şekilde oluşturuldu. Üretilen LVL'ler kaplamaların kullanım yeri ve türüne bağlı olarak kodlandırıldı. BBBBBBB, BBPPPBB, PPPPPPP ve PPBBBPP sırasıyla I.grup, II. Grup, III. Grup ve IV. Grup olarak isimlendirildi. Fiziksel özellikler olarak fırın Kurusu özgül ağırlık ve rutubet değerleri TS 2472 (1976a) ve TS 2471 (1976b) standartlarına göre belirlendi. Yapışma mukavemeti, eğilme direnci, eğilmede elastikiyet modülü ve liflere paralel basınç direnci gibi mekanik özellikler sırasıyla EN 314-1 (2004), EN310 (1993) ve TS 2595 (1977) standartlarına göre belirlendi. Bu çalışmada en yüksek direnç ve yoğunluk değeri tamamı kayın kaplamalarından üretilen I. Grup LVL'lerde elde edildi. Diğer yandan en düşük değerler tamamı kavak kaplamalarından üretilen III. Grup LVL'lerde gözlemlendi. Kayın kaplamalarının LVL' ye katılım oranının direnç ve yoğunluk değerlerinde bir artış sağladığı söylenebilir.
Anahtar Kelimeler: Lamine kaplama kereste (LVL), Melamin formaldehit, kavak, kayın, Elastikiyet modülü, Tutkal

1 Introduction

Laminated veneer lumber (LVL), a lumber-like product, is an engineered wood product which is manufactured from sliced, peeled or sawed veneers, glued parallel to the longitudinal axis of the member.

LVL can provide higher wood utilization rate compared to solid wood, improved strength, more available sizes, better performance predictability, dimensional consistency, dimensional stability and treatability [1]. LVL used in building construction as farming members such as girders, joists, beams, headers and columns, as well as panels because of these properties [1].

Quality properties of the LVL can be affected by the type of solid wood and their density, physical and mechanical properties, composition of wood species used for veneers, thickness of the veneers, type and amount of adhesives used and their bonding performance with veneers. The most using adhesives in LVL manufacturing for structural applications in exterior conditions are phenol formaldehyde (PF) and phenol resorcinol formaldehyde (PRF). If LVL is used semi-structural and non-structural applications in interior conditions, UF is recommended as adhesive. Melamine formaldehyde (MF) is expensive. However, compared to UF, it has better water resistance, higher temperature stability, curing ability at low temperatures and without hardener [2, 3].

Beech and poplar are very common wood species harvested in Turkey. Poplar is low-cost and very fast growing tree species in general. Beech, on the other hand, more expensive and have relatively better structural properties than poplar. Both tree species have several different application areas. Manufacture of engineered wood composites utilizing these trees is important. Utilization of poplar wood in LVL manufacturing was reported by Uysal and Kurt [4], Burdurlu et al. [5] and Kurt and Mengeloglu [6].

In this laboratory study, LVL was manufactured with selected beech and poplar veneers in different layers using MF adhesives. The suitability of poplar and beech combinations in LVL manufacturing were evaluated. For this purpose, physical

(oven dry specific gravity and moisture content) and mechanical (glue line shear strength, compression strength, modulus of rupture and modulus of elasticity) properties of manufactured LVLs were determined.

2 Materials and Methods

2.1 Wood Veneers

In LVL manufacturing was used sawed veneers of poplar and beech with dimensions of approximately 500mm x 140mm x 3mm and moisture content of 6-8%. They provided from Dal timber trade in Hatay, Turkey.

2.2 Adhesive

A commercial MF was used as adhesive. MF adhesive has a solid content of 53±1% with a pH of 9.40, and density of 1.230 g/cm^3 at 20 ºC (MF adhesive was provided from Kastamonu integrated factory in Adana, Turkey). The adhesive using rate was 200g/m^2 (ASTM D899).

2.3 LVL Manufacturing

Beech and poplar veneers were used in LVLs with different combinations (Table 1). After spreading adhesives to veneers surfaces', LVLs were formed four surface layers (two top surfaces and two subgrade) and three core layers. Two of LVLs were produced with only beech or poplar veneers. Third one was consisted of beech surface layers and poplar core layers while another one was consisted of poplar surface layer and beech core layers. Sample code and order of laminates is presented Table 1. Billets were pressed at 200 ºC, 10 min and a pressure of 50 Bar with their grain directions parallel to each other. Manufactured LVLs were cut in accordance with test dimensions. Dimensions and shapes of specimens are given in Table 2.

Table1. Sample code and order of laminates.

Sample Code	Order of The Laminates
I	BBBBBBB
II	BBPPPBB
III	PPPPPPP
IV	PPBBBPP

2.4 Testing

Moisture content (MC) and oven dry specific gravity (SG) of manufactured LVLs were determined in accordance to TS 2471 and TS 2472, respectively.

The mechanical properties and standards are given in Table 3. Specimens of Glueline Shear Strength were modified as in Anonymous 1997. The glue bond quality specimens' forms, dimensions and shapes are shown in Fig.1. The Shear Strength was determined for one of seven gluelines, this being 3/4 layers.

Table3. Mechanical Properties and Standards.

Properties of Mechanical	**Standards**
Modulus of Rupture (MOR)	EN310
Modulus of Elasticity (MOE).	EN310
Compression Strength (CS) (parallel to grain)	TS 2595
Glueline Shear Strength	EN314-1

Specimens were conditioned at a relative humidity of 65% and a temperature of 20 °C for at 14 days before testing. The specimens were tested using a ZwickRoell (Z010) testing (Zwick,Germany).

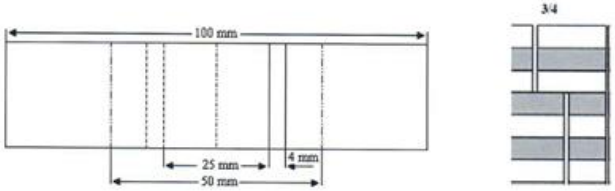

Fig.1.Glue bond quality specimens' form and dimensions.

Table2. Dimensions and Shape of Specimens for Specified Tests

Test	Dimensions (mm)	Shape
Oven-dry specific gravity (SG) Moisture content (MC)	20(t) x 30(w) x 30(l)	
Modulus of rupture (MOR) Modulus of elasticity (MOE)	18(t) x 50(w) x 400(l)	
Compression strength parallel to grain(CS)	20(t) x 20(w) x 30(l)	
Glueline shear strength (GSS)	20(t) x 25(w) x 100(l)	

2.5 Statistical Analysis

One-way ANOVA with 4 levels was applied for statistical analysis using Design-Expert® Version 7.1.6.

3 Results and Discussion

The specimens were cut from the manufactured LVLs for air-dry specific gravity, glueline shear strength, modulus of rupture, modulus of elasticity and compression strength parallel to grain measurements. Measured properties of the LVLs were presented in Table 4.

Table4. Average values of the studied properties of the LVLs.

Properties	LVL			
	I	II	III	IV
SG (g/cm^3)	0.739 (0.027)	0.635 (0.011)	0.492 (0.015)	0.586 (0.040)
MOR (MPa)	120.41 (7.43)	97.16 (17.70)	48.59 (4.77)	53.31 (17.42)
MOE (MPa)	11009.7 (395)	10309.9 (1347)	5277.9 (490)	5522.8 (1110)
CS (MPa)	70.71 (2.69)	59.70 (6.29)	32.46 (2.47)	48.70 (3.67)
GSS 3/4	6 (0.4)	5.1 (0.6)	1.9 (0.5)	4.4 (1.4)

The average oven-dry specific gravity (SG) values were in the ranged of 0.492 to 0.739 g/cm^3 (Table 3). Interaction graph of density values were presented in Figure 2. Type and combination of the veneer had a significant effect on SG values

(P<0.0001). It was higher when beech veneer was used. Lowest SG values were observed when poplar veneers were utilized.

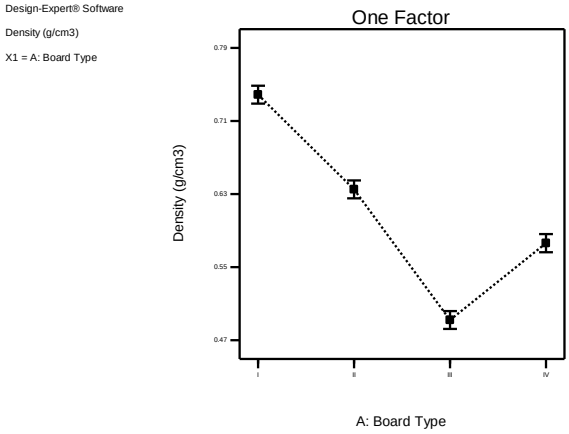

Fig.2. Interaction graph density values of the samples

Interaction graph of shear strength (GSS) values were presented in Figure 3. The average GSS values between 3/4 Glueline were in the ranged of 1.9 to 6 g/cm^3 (Table 3). Type and combination of the veneer had a significant effect on GSS values (P<0.0001). It was lower when poplar veneer was used. Highest GSS values were observed when beech veneers were present in LVL manufacturing.

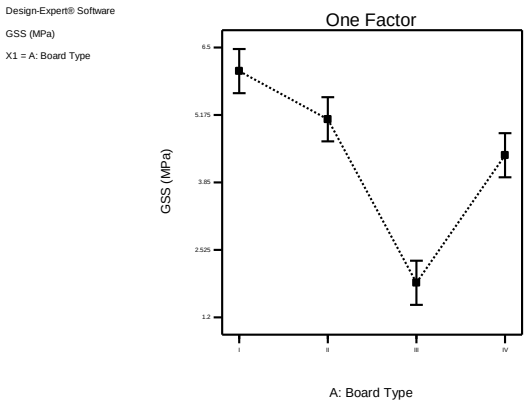

Fig.3. Interaction graph of glue shear strength (GSS) values of the samples

The average Modulus of rupture (MOR), Modulus of elasticity (MOE) and Compression strength parallel to grain (CS) values of LVLs ranged from 48.5-120.4, 5277.8-11009.6 and 32.4-70.7 MPa, respectively (Table 3). Type and combination of the veneer had a significant effect on MOR, MOE and CS values (P<0.0001). Interaction graphs of MOR, MOE and CS values were presented in Figure 4, Figure 5 and Figure 6, respectively. Highest properties were reached when beech veneer was used. On the contrary, presence of poplar veneer drastically reduced the MOR, MOE and CS values. It should be noted that the veneers used in this study were not sawed in our laboratories. Surface of the veneers were not in a perfect shape for the bonding and there were some thickness varieties among the beech and poplar veneer. These impurities may affect the bonding performance of the glue, homogenous thickness and density in manufactured LVLs.

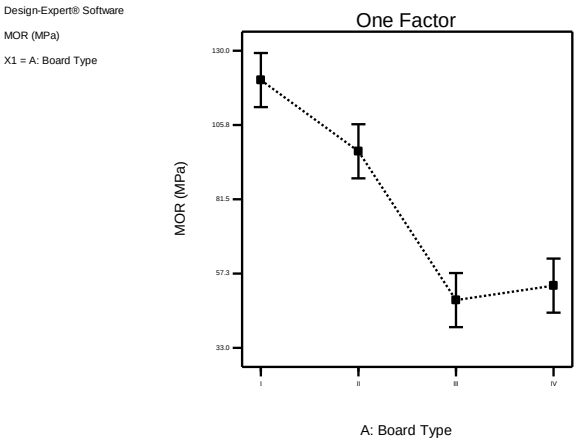

Fig.4. Interaction graph of modulus of rupture (MOR) values of the samples

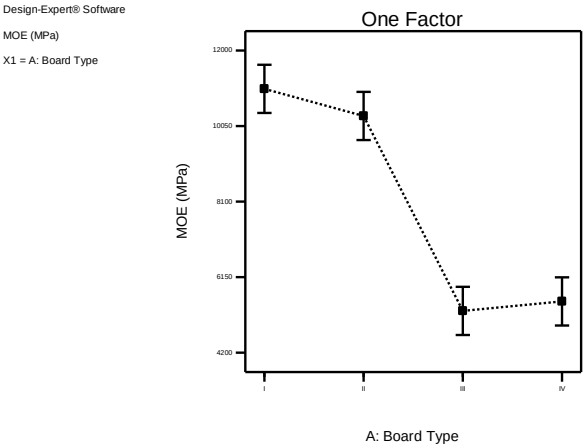

Fig.5. Interaction graph of modulus of elasticity (MOE) values of the samples

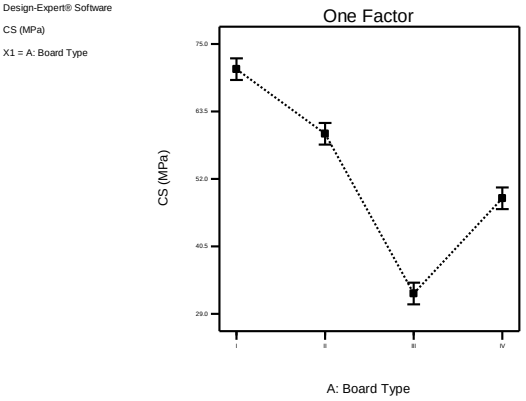

Fig.6. Interaction graph of compression strength (CS) values of the samples

4 Conclusions

1. The potential use of beech and poplar woods for LVLs manufacturing were determined. LVLs were manufactured

from sawed poplar and beech veneers with the MF adhesive successfully.

2. Combination types had significant effect on physical and mechanical properties of LVLs. I group LVLs had the highest and III group LVLs had the lowest SG, MOR, MOE, and CS values among three different wood species.
3. As proportion of beech veneer in LVL increased, strength values of LVLs raised also.

This study should be supported by a follow up studies by collecting the logs and preparing veneers. Cutting solid samples and comparing them with LVLs manufactured with veneers from the same logs should be done in the future studies.

5 Acknowledgement

This study was presented as an oral presentation at the II. International Furniture Congress (IFC 2016), 13-15 October 2016, Muğla, Turkey.

6 References

[1] Nelson, S. "Structural composite lumber," In: *Engineered Wood Products*: A Guide for Specifiers, Designers, and Users, Smulski, S. (Ed.), PFS Research Foundation, Madison, 1997.147-152.

[2] Pizzi, A., "Wood Adhesives": *Chemistry and Technology*, Vol. 1, Marcel Dekker, New York. 1983.

[3] Nemli, G. ve Çolak, S.," Melamine and urea formaldehyde glue in the laminate industry", *Wood Machinery*, 2002. 4,46-48.

[4] Uysal, B.., and Kurt, S. "Dimensional Stability of laminated veneer lumbers manufactured from using different adhesives after the steam test, "GU J. Sci. 2005. 18(4), 681-691.

[5] Burdurlu, E.,Kilic, M., Ilce, A.C., and Uzunkavak, O. "The effect of ply organization and loading on bending strength and modulus of elasticity in laminated veneer lumber (LVL) obtained from beech (Fagusorientalis L.) and Lombardy poplar (Populus nigra L.),"*ConstrBuild Mater* 21, 2007. 1720-1725.

[6] Kurt, R., and Mengeloglu, F." The effect of boric acid/borax treatment on selected mechanical and combustion properties of poplar laminated veneer lumber," Wood Res-Slovakia 53(2), 2008.113-120.

[7] ASTM D899. "Standard test method for applied weight per unit area of liquid adhesive, "*American Society for Testing Materials*, Philadelphia. 1994.

[8] TS 2472."Wood, determination of density for physical and mechanical tests," *Turkish Standard Institution*, Ankara. 1976a.

[9] TS 2471. "Wood, determination of moisture content for physical and mechanical tests, " *Turkish Standard Institution*, Ankara. 1976b.

[10] EN314-1. "Plywood-Bonding quality Part 1: Test methods," *European Standardization Committee*, Brussels. 2004.

[11] Anonymous. "An investigation and evaluation of laminated veneer lumber (LVL) manufactured from European hardwoods," *Copernicus ELVE* (European Laminated Veneer Engineering) Project Final Report. 1997.

[12] EN 310," Wood Based Panels, Determination of Modulus of Elasticity in Bending and Bending Strength," *European Committee for Standardization*, Brusselles, Belgium. 1993. TS 2595. "Wood, determination of ultimate stress in compression parallel to grain, "Turkish Standard Institution, Ankara. 1977.