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COMPRESSION AND BONDING STRENGTH OF HEAT TREATED SCOTCH PINE (Pinus Slyvestrist L.) WOOD BONDED WITH D-VTKA ADHESIVE

ABSTRACT

Heat treatment is usually applied to wood species to improve their properties. This study examined the effects of heat treatment on compression and bonding strength properties of Scotch pine (*Pinus sylvestris* L.), which has industrially high usage potential in wood working industry. Test samples were exposed to heat treatment under varying temperatures (110, 130, 150 and 170°C) for varying durations (2 and 6 h.). Compression and bonding strength tests were performed according to TS 2470, BS EN 204 respectively. The results indicated that the highest values were measured in control samples. It can be said that the heat-treatment process was decreased mechanical properties which including compression and bonding strength.

Keywords: Bonding Strength, Compression, Heat Treatment, Scotch Pine, Mechanical Properties

ISIL IŞLEM UYGULANMIŞ D-VTKA TUTKALI ILE YAPIŞTIRILMIŞ SARIÇAM (Pinus Slyvestrist L.) ODUNUN YAPIŞMA VE BASINÇ DIRENCI

ÖZET

Isıl işlem genellikle ahşap malzemenin özelliklerini iyileştirmek için uygulanır. Bu çalışmada, ahşap sektöründe yaygın olarak kullanılan sarıçam (Pinus sylvestris L.) odununda ısıl işlem uygulamasının basınç ve yapışma direnci gibi bazı mekaniksel özelliklere etkisi incelenmiştir. Test örnekleri 2 ve 6 saat süre ile 110, 130, 150 ve 170°C sıcaklıkta ısıl işleme maruz bırakılmıştır. Test örneklerinde basınç ve yapışma direnci deneyleri sırasıyla TS 2470, BS EN 204 standartlarına göre yapılmıştır. Test sonuçlarına göre en yüksek değerler kontrol örneklerinde ölçülmüştür. Isıl İşlem uygulamaları basınç ve yapışma direnci gibi mekaniksel özellikleri azalttığı söylenebilir.

Anahtar Kelimeler: Yapışma Direnci, Sıkıştırma Direnci, Isıl İşlem, Sarıçam, Mekanik Özelikler

1. GİRİŞ (INTRODUCTION)

Heat treatment is one of the processes used to modify the properties of wood. And heat treatment, as a wood modification method, serves to improve the natural quality properties of the wood, such as dimensional stability and resistance to bio-corrosion and equip the wood material with new properties [1].

In the high temperature treatment process, the wood is subjected to higher temperatures than those used during conventional drying (up to 200–230°C). The process is one of the alternatives to the chemically treated wood which is not considered environmentally friendly. The heat treatment not only removes the moisture from the wood, but also modifies its structure reducing its hemicellulose content [2]. With this process, wood also becomes more resistant to biological attacks such as fungal degradation [3]. It was mentioned that wood exposed to high temperatures changes its physical and chemical properties [4]. According to Viitaneimi (1997), the effects of thermal treatment of wood at temperatures between 185°C and 250°C are reduction of the equilibrium moisture content (EMC) by 43%–60%, shrinkage and swelling reduction of 30%–80% and a reduction of bending strength by 5%–25% [5].

It can be said that wood becomes more brickle by heat treatment. The tensile strength of Maple (Acer sp.) was increased by heat treatment at 400 F for 4.5 h. [6]. The bending strength of Hinoki wood (Chamaecyparis obtusa Endl.) heat-treated at 100-176°C for 2-10h. became greater than that of untreated wood [7]. According to Kitahara and Chuganji, the modulüs of rupture in the bending of Hinoki wood and Buna wood (Fagus crenata) were not changed by 150~ treatment and were decreased to 50% that of untreated wood by 200°C treatment. The absorbed energy in impact bending was seriously decreased by the 150 - 200 °C treatments. [8]. Sato et al., have reported that the fracture toughness decreases as the temperature exceeds 120°C [9].

2. ÇALIŞMANIN ÖNEMİ (RESEARCH SIGNIFICANCE)

The heat treated wood has a growing market in outdoor and indoor applications such as cladding window, door joinery, flooring, paneling, kitchen furnishing and saunas. The main objective of this study was to evaluate the bonding strength performance and compressive strength of heat treated Scotch pine wood.

3. MALZEME VE YÖNTEM (MATERIAL AND METHOD)

The Scotch pine (*Pinus slyvestrist L.*) wood was chosen randomly from timber merchants of Karabuk, Turkey. The special emphasizes was put on the selection of wood material. Accordingly, non-deficient, proper, knotless, normally grown (without zone line, reaction wood, decay, insect and mushroom damages) wood material were selected. The selected specimens were cut at the sizes of 50×100×200 mm and they exposed to heat treatment at 110, 130, 150, and 170°C during 2 and 6 hours. Then, they were re-sized to relate to standards (BS EN 204 and TS 2470) [10 and 11]. The bonding test samples were bonded with the D-VTKA adhesive which was applied at rate of about 180 g/m^2 on single bonding surface according to advice of manufacturer.

The measurements of compression and bonding strength tests were carried out in a Zwick/Roel Z50 universal test machine with capacity of 5000 kg and measurement sensitive of 0.01N in accuracy was used. Obtained from experimental works data was statistically analyzed. Analysis of variance (ANOVA) was used to test for significance between factors and levels. When the ANOVA pointed a significant difference

among the factors and levels, a comparison of the means was conducted employing a Duncan test.

4. RESULTS AND DISCUSSION (SONUÇLAR VE TARTIŞMA)

According to experiment conditions the average bonding and compressive strength values and standard deviation values are given Table1.

Table1. Bonding and compression strength test results
(Tablo 1. Sıkıştırma gücü test sonuçları bağlar)

Experiment Conditions		Bonding Strength (N/mm^2)		Compression Strength (N/mm^2)	
Temperature (°C)	Time (h.)	Mean	Std. Deviation	Mean	Std. Deviation
Control	Control	8.26	1.33	45.62	9.27
110	2	5.86	0.65	46.81	3.08
110	6	5.10	0.30	55.87	14.13
130	2	4.97	0.97	58.95	10.41
130	6	4.92	1.14	59.21	5.32
150	2	4.85	0.88	60.47	10.57
150	6	3.29	1.14	58.35	9.16
170	2	3.08	0.97	59.57	12.57
170	6	2.13	0.74	54.51	3.52

The values show that heat treatment diminished the bonding and compressive strength of test samples. The highest value of bonding strength was determined as a result of control test samples (8.26 N/mm^2). The lowest value of bonding strength (2.13N/mm^2) was obtained from heat treatment samples that are exposed to 170°C temperature for 6 hours. The heat treatment caused to decreasing of bonding strength. Uysal, (2005) have reported that the highest shear strength of Scotch pine wood bonded with D-VTKA adhesive was obtained (6.18 N/mm^2) [12].

The highest compression strength (60.47 N/mm^2) was obtained from the heat treatment samples (150°C and 2 h.) The lowest compression strength value (45.62 N/mm^2) was determined at the control samples. The compression strength results showed that heat treatment was increased to these values. However, compression strength values were decreased after 150°C temperature heat treatment for 2 hours. It's reported that when scotch pine wood was exposed to heat treatment, it's compression strength value was increased [13].

Variance analysis was used in order to determine whether or not variables and their interactions with each other were influential on the bonding strength according to the values given in Table 2. Likewise, the variance analysis of compression strength was conducted (Table 3).

Table 2. Multiple variance results of bonding strength
(Tablo 2. Yapışma gücü çoklu varyans sonuçları)

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F-Value	Sig. ($p \leq 0.05$)
A	75.43	3	25.14	27.91	0.00
B	11.04	1	11.04	12.26	0.00
A *B	4.63	3	1.54	1.71	0.17
Error	56.75	63	0.90		
Total	1863.12	72			
A: Temperature (control-110-130-150-170 °C) B: Time (control-2-6 hours)					

According to the results of the variance analysis, the heat temperature and holding periods are influential on the bonding strength, but their interactions isn't on it. At the same time, it was determined that these variables were also influential ($p \leq 0.05$) on compression strength (Table 3).

Table 3. Multiple variance results of compression strength
(Tablo 3. Sıkıştırma gücü çoklu varyans sonuçları)

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F-Value	Sig.($p \leq 0.05$)
A	669.70	3.00	223.23	2.52	0.05
B	4.62	1.00	4.62	0.05	0.82
A * B	444.07	3.00	148.02	1.67	0.18
Error	5584.40	63.00	88.64		
Total	229228.38	72.00			
A: Temperature (control-110-130-150-170 °C) B: Time (control-2-6 hours)					

The difference between the groups regarding the effect of variance sources on bonding and compression strength was significant ($p \leq 0.05$). Duncan test results, conducted to determine the importance of differences between the groups are given Table 4. According to Duncan test results, it can be said that bonding and compression strength values were affected with heat treatment of wood samples.

Table 4. Duncan test results
(Tablo 4. Duncan test sonuçları)

Experiment Conditions		Bonding Strength		Compression Strength	
		Mean	HG	Mean	HG
Temperature (°C)	Control	8.26	A	45.62	A
	110	5.48	C	51.34	AB
	130	4.95	C	59.08	C
	150	4.07	B	59.41	C
	170	2.61	D	57.04	BC
Time (h.)	Control	8.26	A	45.62	A
	2	4.69	B	56.45	B
	6	3.86	C	56.99	B

5. CONCLUSION (SONUÇ)

In this study on Scotch pine (*Pinus sylvestris* L.) wood, it was found that compression strength parallel to grain and compressive bonding strength decrease by heat treatment. Moreover, the experimental results showed that an increase in time and duration resulted in greater decreases in treated samples compared to the control samples. On the other side, the smallest decreases for bonding strength were observed in the treatment at 110°C for 2 h. The highest increases for compression strength values were occurred in the treatment at 150°C for 2 h. But, because of the degradation of wood components the compressive strength values were decreased after this level. When heat treatment exposed of wood that decreased of mechanical and physical properties of wood was reported in the literature.

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