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Effects of Impregnation with Tanalith-E on the Compression Strength of Some Woods

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ABSTRACT

This study was performed to determine the effects of impregnation with Tanalith-E on compression strengths of Oriental beech (*Fagus orientalis* Lipsky), European oak (*Quercus petraea* Liebl.), Black walnut (*Junglans nigra* Lipsky), Lombardy poplar (*Populus nigra* Lipsky), Ash (*Fraxinus exelsior* Lipsky) and Scotch pine (*Pinus sylvestris* Lipsky) woods. For this aim, the wood samples were prepared according to TS 345 and impregnated with Tanalith-E by the method of the vacuum according to ASTM D 1413 and producers' definition. After impregnation process, compression strength was measured according to TS 2595. Consequently, compression strengths of wood un-impregnated were found higher (approximately 6.63%) than impregnated with Tanalith-E wood materials. Accordingly, the highest values of compression strengths were obtained in impregnated Oriental beech and ash woods, whereas the lowest values were obtained in the Lombardy poplar wood.

Keywords : Compression strength, Tanalith E, impregnation, woods.

ÖZ

Bu çalışma, su bazlı Tanalith-E ile emprenye etmenin ağaç malzemelerin (Doğu kayını (*Fagus orientalis* Lipsky), Sapsız meşe (*Quercus petraea* Liebl.), Kara ceviz (*Junglans nigra* Lipsky), Kavak (*Populus nigra* Lipsky), Dişbudak (*Fraxinus exelsior* Lipsky), Sarıçam (*Pinus sylvestris* Lipsky)) basınç direncine etkilerini belirlemek amacıyla yapılmıştır. Bu maksatla; kayın, meşe, ceviz, kavak, dişbudak ve sarıçam odunlarından TS EN 345 esaslarına göre hazırlanan deney örnekleri Tanalith-E ile ASTM D 1413 esaslarına uyularak vakum yöntemi ile emprenye edilmiştir. Emprenye edildikten sonra basınç direnci değerleri TS 2595 standardı esaslarına göre belirlenmiştir. Sonuç olarak, emprenyesiz örneklerin emprenye edilmiş örneklere göre; basınç direnci değeri yaklaşık olarak % 6.63 daha yüksek bulunmuştur. Tanalith-E ile emprenye edilmiş ağaç malzemelerin basınç direnci değerleri en yüksek kayın ve dişbudakta, en düşük değerler ise kavak odununda elde edilmiştir.

Anahtar Kelimeler : Basınç direnci, tanalith e, emprenye, ağaç malzemeler.

1. INTRODUCTION

Preserving wood materials from environmental effects and providing long usage periods are economically important. If the wood materials are used without processing by preservative chemicals (with regard to the area of usage), fungal stains, insect infestation, humidity, fire etc. damage the wood. As a result of these damages, the woods require to be repaired, maintained or replaced before its economic life ends [1]. For this reason, in most places the wood materials should be impregnated with some chemicals. In the case of wood is not impregnated but only painted and varnished instead, the prevention on the surfaces is limited to a maximum of two years [2].

It is reported that, in mines, as a result of the impregnation of the beech and spruce wood with water-soluble salts, the bending, tens ile and impact strength decreased a little whereas compression strength increased [3]. In another research concerning the impregnation of pine, spruce, fir, beech and poplar woods with Antrasen, it was found that, the compression strength increased by 6–40% and bending strength increased by 10–22% [4].

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It was assessed that, salty impregnation materials increased the compression strength by 4.6–9.6%, whereas decreased the bending strength by 2.9–16% [5]. In another study, chromate copper arsenate (CCA) and arsenate copper arsenate (ACA) salts did not cause any significant impact on modulus of elasticity in bending [6].

Impregnation of alder (*Alnus glutinosa* L.) with vinylmonomers increased the compression strength [7]. In another study, impregnation of Scotch pine and Oriental spruce with zinc clor and sulphate did not cause to a decrease in the compression strength [8].

In the interaction of wood material and impregnation period, the highest compression strength values were found in the samples impregnated with long-term dipping method whereas the lowest in the samples impregnated with shortterm dipping method. The compression strength in long-term dipping increased 11.4% in beech, 15.2% in oak, 21.6% in pine, 16.5% in spruce, 11.9% in fir and 12.3% in poplar. The amount of impregnation material penetrated into the wood cause to increase in compression strength [9].

In this study, Oriental beech, European oak, Black walnut, Lombardy poplar, Ash and Scotch pine woods commonly being used in furniture manufacturing and massive constructions were examined with respect to the effects of impregnation with Tanalith-E on the compression strength.

2. MATERIAL AND METHOD

2.1. Material

2.1.1. Wood materials

The Oriental beech (*Fagus orientalis* Lipsky), European oak (*Quercus petraea* Liebl.), Black walnut (*Junglans nigra* Lipsky), Lombardy poplar *(Populus nigra* Lipsky*)*, Ash (*Fraxinus exelsior* Lipsky) and Scotch pine (*Pinus sylvestris* Lipsky) woods to be used as test sample was chosen randomly from the timber merchants in Ankara. Special emphasis is given for the selection of wood materials. Accordingly, non-deficient, proper, knotless, normally grown (without zone line, without reaction wood, without decay and insect mushroom damages) wood materials were selected.

2.1.2. Impregnation material

Tanalith-E, used as an impregnation material in this study was supplied from Hemel (Hemel-Hickson Timber Products Ldt.), Istanbul. Tanalith-E is not contain chromium or arsenic, non- flammable, fluent, water-based, completely, soluble in water, non-corrosive material with a pH value of 7 and a density of 1.04 $g.cm^{-3}$. It is available as a ready-made solution. Tanalith-E wood preservative contains a copper compound and azole biocides. Storage in a frost free environment is recommended [10].

2.2. Method

2.2.1. Preparation of the test samples

The rough drafts for the preparation test and control samples were cut from the sapwood parts of massive woods and conditioned at a temperature of 20±2 ^{0}C and 65±3 % relative humidity for three months until reaching an equilibrium in humidity distribution. The samples for compression strength test, with a dimension of 20x20x30 mm were cut from the drafts having an average humidity of 12 % according to TS 2595 [11]. The densities and humidity values of all test samples were measured before the impregnation process. The test samples were impregnated by the method of the vacuum according to ASTM D 1413 [12], TS 344 [13] and TS 345 [14]. The specifications of the impregnation solution were determined before and after the process. The processes were carried out at 20±2 ^{0}C temperature. Retention of impregnation material (*R*) was calculated by the formula;

$$R = \frac{G.C}{V} 10^3 \ kg.m^{-3} \qquad G = T_2 - T_1 \qquad (1)$$

Where *G* is the amount of impregnation solution absorbed by the sample (g), T_2 is the sample weight after the impregnation (g), T_1 is the sample weight before the impregnation (g), *C* is the concentration (%) of the impregnation solution and *V* is the volume of the samples (cm^3).

Impregnated test samples were kept under a temperature of 20±2 ^{0}C and 65±3 % relative humidity until they reach to a stable weight.

2.2.2. Compression strength

The tests for compression strength parallel to grains of wood materials were carried out with Universal Testing Machine shown in Figure 1, according to TS 2595. The capacity of Universal Testing Machine was 400 N. The speed of testing machine was adjusted to 5 mm/min. for crashing to occur in 1-2 minutes.

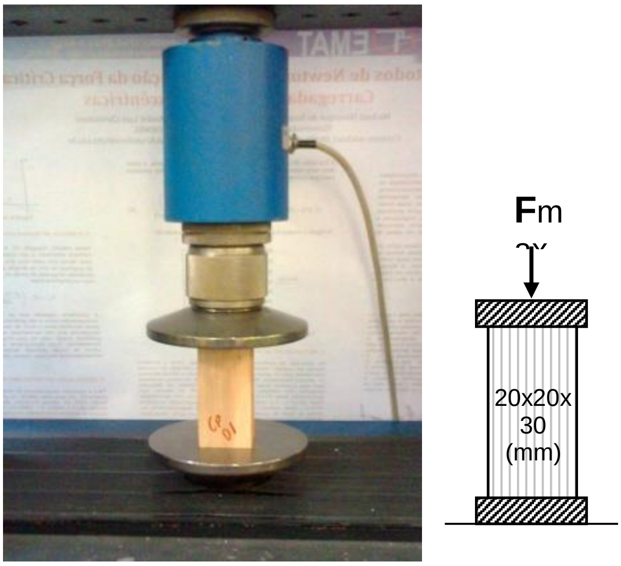

Figure 1. Compression strength test in a universal testing machine

Compression strength was calculated by the formula;

$$\sigma_b = \frac{F_{\max}}{ab} N.mm^{-2} \qquad (2)$$

Where F_{max} is the breaking load on the scale (N), *a* is the cross-sectional width of test sample (mm), *b* is the cross-sectional thickness of the test sample (mm).

2.3. Data Analysis

The results were analyzed statistically by computer software, SPSS 15.0 for Windows. A total of 24 treatment groups was obtained with 4 compression test sample and one control sample. Ten replications were made in each test group. Thus, a total of 120 samples (6x2x10) were prepared. The effects of impregnation with Tanalith-E on compression strength of the woods were analyzed by ANOVA (Analysis of Variance). Duncan Test was also applied where appropriate.

3. RESULTS AND DISCUSSION

3.1. Retention Amount

Statistical values pertaining to averages of retention amount of experimented samples have been given in Table 1.

Table 1. Statistical values belong to averages of retention amount

Statistical values	WOOD MATERIALS					
	Beech	Oak	Walnut	Poplar	Ash	Pine
X *(kg.m^{-3})*	138.357	85.617	81.086	76.149	94.929	70.391
Ss *(kg.m^{-3})*	5.46626	4.27868	2.03932	8.962018	3.1171408	4.55572
v *(s²)*	33.2000	20.3412	4.62095	89.24197	10.796185	23.0607
min *(kg.m^{-3})*	129.481	76.348	79.035	66.356	90.032	62.348
max *(kg.m^{-3})*	146.321	93.024	86.356	91.662	99.032	78.356
N	10	10	10	10	10	10

Table 2. Result of the retention amount variance analysis (ANOVA)

Variance Source	Squares Sum	Degree of Exemption	Averages of Squares	F value	Sig.
Inter Group	30306	5	6061.246	200.636*	0.000
In-Group	1631.351	54	30.210		
TOTAL	31937.58	59			

*P< 0.05

According to F test which has been done to determine retention amount of wood materials; retention amounts have been differed from as per wood materials in statistical context ($F_{(5;54)}$=200.636, P<0.05). According to DUNCAN test results that are related to this (Table 3); highest retention amount has been obtained from oriental beech, then Ash, Oak, Black Walnut, Black Poplar, and Scotch Pine follow up, respectively. Mathematical difference between Oak and Black Tree has not been found relevant in statistical context.

Table 3. Retention amount related DUNCAN test result

Groups	N	For sub-groups α = 0,05				
		1	2	3	4	5
Scotch Pine	10	70.391				
Poplar	10		76.149			
Walnut	10			81.086		
Oak	10			85.617		
Ash	10				94.929	
Beech	10					138.357
SIGNIFICANT		1.000	1.000	10.071	1.000	1.000

According to wood materials, the highest retention amount has been obtained from Oriental beech with 138.357 kg.m^{-3} and then Ash 94.929 kg.m^{-3}, Oak 85.617 kg.m^{-3}, Black Walnut 81.086 kg.m^{-3}, Black Poplar 76.149 kg.m^{-3} and Scotch Pine 70.391 kg.m^{-3} have followed up it, respectively. The main reason of the highest level of retention amount in Oriental beech may stem from high permeability ratio. In fact, in literature, retention amounts of wood materials which were impregnated by dipping method with Imersol-Aqua; on Oriental beech 274.728 kg.m^{-3} gained, and then on oak 44.936 kg.m^{-3}, on Scotch pine 68.538 kg.m^{-3}, on Uludag fir 79.180 kg.m^{-3}, on spruce 92.225 kg.m^{-3} and on Black Poplar 75.405 kg.m^{-3} followed up, respectively [15].

3.2. Compression Strength

Statistical values of compression strength of impregnated wood materials and control samples have been given in Table 4.

Table 4. Statistical values of compression strength

Statistical values	IMPREGNATED WOOD MATERIALS					
	Beech	Oak	Walnut	Poplar	Ash	Pine
X *(N.mm^{-2})*	66.771	62.748	59.638	37.758	69.676	54.207
Ss *(N.mm^{-2})*	2.06912	2.41847	2.15121	2.20096	3.641582	1.63439
v *(s²)*	4.75698	6.49890	5.14192	5.38248	14.73458	2.96804
min *(N.mm^{-2})*	63.25	59.05	54.32	34.35	64.64	51.73
max *(N.mm^{-2})*	69.83	66.25	62.51	39.74	76.63	57.36
N	10	10	10	10	10	10
UN-IMPREGNATED CONTROL SAMPLES						
X *(N.mm^{-2})*	68.965	64.612	61.812	40.844	72.164	54.953
Ss *(N.mm^{-2})*	2.52653	2.22249	3.07068	1.71388	4.246530	3.12027
v *(s²)*	7.09265	5.48830	10.4767	3.26378	20.03669	10.8179
min *(N.mm^{-2})*	64.82	60.12	56.35	38.03	62.34	50.03
max *(N.mm^{-2})*	73.25	68.62	69.03	44.35	78.35	59.03
N	10	10	10	10	10	10

According to F Test which has been done for determination compression strength of impregnated wood materials (Table 5); compression strength values indicates significant differences according to type of wood material in statistical context ($F_{(5;54)}$=200.990, P<0.05). According to Duncan test results which is related to this; the highest compression strength value has been obtained from Ash wood and then on Oriental beech, Oak, Walnut, Scotch Pine and Black Poplar followed up, respectively (Table 6).

According to T test which has been done to figure out compression strength of Impregnated massive wood material and un-impregnated control samples (Table 7); difference between compression strength have been determined significantly as 0.05 tolerance which is smaller than un-impregnated poplar samples. Mathematical differences in compression strength values between other wood materials have not been found significant.

Compression strength values parallel to grains of wood materials (control samples) which were not impregnated have not been found significant according to impregnated with Tanalith-E wood materials (except poplar) (Table 8). However on impregnated poplar wood, compression

Table 5. Compression strength variance analysis results

Variance Source	Squares sum	Degree of exemption	Averages of Squares	F value	Sig.
Inter Group	6613.066	5	1322.613	200.990*	0.000
In-Group	355.346	54	6.580		
TOTAL	6968.412	59			

*P< 0.05

Table 6. Compression strength DUNCAN test's results

GROUPS	N	For sub-groups α = 0,05					
		1	2	3	4	5	6
Poplar	10	37.758					
Pine	10		54.207				
Walnut	10			59.638			
Oak	10				62.748		
Beech	10					66.771	
Ash	10						69.676
SIGNIFICANT		1,000	1.000	1.000	1.000	1.000	1.000

strength values were average 8.173 % lower according to control samples. It may be the result of weakening effects of impregnation material on cohesion strength between poplar woods' grains.

Table 7. Compression strength T test results

WOODS	N	X	Ss	SD	SIG.(T)*
Scotch Pine (E) Scotch Pine (K)	10 10	54.207 54.953	1.7228 3.2891	18	0.536^{NS}
Walnut (E) Walnut (K)	10 10	59.638 61.812	2.2676 3.2368	18	0.099^{NS}
Ash (E) Ash (K)	10 10	69.676 72.164	3.8386 4.4762	18	0.199^{NS}
Poplar (E) Poplar (K)	10 10	37.758 40.844	2.3200 1.8066	18	0.004
Beech (E) Beech (K)	10 10	66.771 68.965	2.1811 2.6632	18	0.06^{NS}
Oak (E) Oak (K)	10 10	62.748 64.612	2.5493 2.3427	18	0.106^{NS}

*P<0.05, N: Number of samples X: Average, E: impregnated sample, K: Unimpregnated control sample, Ss: Standard deviation, SD: Degree of exemption, NS (No significant)

Table 8. Compression strength differences of Impregnated and un-impregnated wood materials

WOOD MATERIALS	Beech	Oak	Walnut	Poplar	Ash	Pine
Impregnated (N.mm^{-2})	66.771	62.748	59.638	37.758	69.676	54.207
Difference ratio (%)	3.285*	2.970*	3.645*	8.173	3.571*	1.376*
Un-impregnated (N.mm^{-2})	68.965	64.612	61.812	40.844	72.164	54.953

*NS (No significant): Difference is no significant according to T test

Compression strength has been obtained highest on ash wood according to wood species and then Oriental beech, Oak, Black Walnut, Scotch Pine, Black Poplar followed up, respectively (Figure 2).

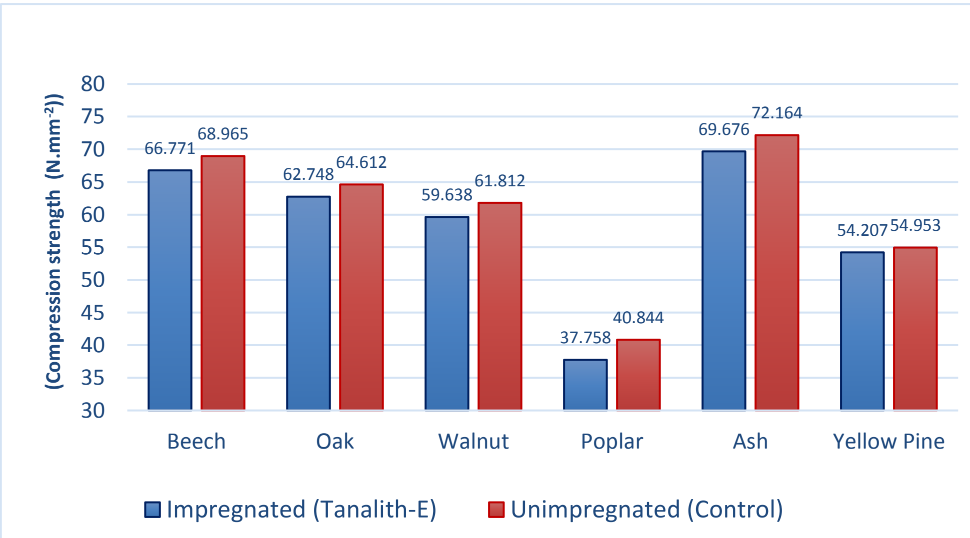

Figure 2. Compression strength values

In Literature, Compression strength values parallel to grains of massive wood materials were declared as Oriental beech 64.4 N.mm^{-2}, Oak 65.5 N.mm^{-2}, Scotch Pine 55.0 N.mm^{-2}, Ash 50.4 N.mm^{-2}, Black Walnut 72.0 N.mm^{-2}, Black Poplar 34.5 N.mm^{-2} [1, 9]. These compression strength values except walnut and ash, the results came close to each other. However, difference between walnut and ash woods may stem from different features of geographical regions of tree samples and experiment samples.

4. CONCLUSION

The highest retention amounts in accordance with wood species were obtained from Oriental beech as 138.357 $kg.m^{-3}$, afterward, in Ash 94.929 $kg.m^{-3}$, in Oak 85.617 $kg.m^{-3}$, in Black Walnut 81.086 $kg.m^{-3}$, in Black Poplar 76.149 $kg.m^{-3}$ and in Scotch Pine 70.391 $kg.m^{-3}$ followed up, respectively. The main reason for highest retention amount in Oriental beech may be the high level permeability of this kind of wood [15].

Compression strength values of impregnated wood materials founded in Oriental beech 66.771 $N.mm^{-2}$, in Oak 62.748 $N.mm^{-2}$, in Black Walnut 59.638 $N.mm^{-2}$, in Black Poplar 37.758 $N.mm^{-2}$, in Ash 69.676 $N.mm^{-2}$ and in Scotch Pine 54.207 $N.mm^{-2}$. Compression strength values of control samples were determined as in Oriental beech 68.965 $N.mm^{-2}$, in Oak 64.612 $N.mm^{-2}$, in Black Walnut 61.812 $N.mm^{-2}$, in Black Poplar 40.844 $N.mm^{-2}$, in Ash 72.154 $N.mm^{-2}$ and Scotch Pine 54.953 $N.mm^{-2}$ respectively. According to F test which was carried out for Compression strengths of impregnated wood materials; compression strength values indicated significant differences in statistical meaning in accordance with wood species ($F_{(5;54)}$ =200.990, $P<0.05$). According to DUNCAN test results which was carried out related this; the highest compression strength was obtained from ash wood, then oriental beech, Oak, Black Walnut, Scotch Pine and Black Poplar followed up, respectively. According to T test results which has been carried out to determine of diversities between compression strengths values of control samples and impregnated wood materials; distinction in Beech, Oak, Ash, Walnut, and Scotch Pine (except Poplar) was insignificant. In the case of impregnated Poplar wood, compression strength value was average 8.17 % ratio lower in accordance with control samples. The reason can be reducing effect of impregnation material on cohesion strength between Poplar woods' grains. Results showed that impregnation material has negative effects only on Poplar wood, it has not any negative effect on beech, oak, ash, walnut and Scotch pine wood.

Accordingly, the highest values of compression strengths were obtained in impregnated Oriental beech and ash woods, whereas the lowest values were obtained in the Lombardy poplar wood. In consequence, in the massive construction and furniture elements that the compression strengths after the impregnation is of great concern, impregnation with Tanalith-E of beech and ash wood materials could be recommended.

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