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The Analysis of the Effects of Open Door Conditions on the Physical and Mechanical Characteristics of Sessile Oakwood Impregnated with Natural and Artificial Substances

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ABSTRACT

In this study; Quality parameters of agricultural irrigation water sources are highlighted. What are the parameters of quality of irrigation water source that can be used in agricultural production may touch upon the subject. In this study, it is aimed to analyze the changes on some physical and mechanical characteristics of sessile oakwood under the effects of open door conditions for one year by impregnating with natural and artificial substances. Pine tannin and acorn are preferred as the natural impregnation material, imersol aqua and lumber aqua are chosen as the synthetic impregnation material. D4 adhesion was used in the experiment on the determination of the bonding resistance parallel to fibers. In the determination of bending resistance and elastic modulus, the samples impregnated with acorn gave better results in comparison with samples impregnated with other substances and the control samples which are not subject to impregnation. The highest value is detected at samples impregnated with timber care aqua in compression resistance parallel to the fibers. In the experiment on the determination of bonding resistance parallel to fibers, close values are found between control samples and samples impregnated with imersol aqua. Samples impregnated with pine tannin is stated to give better results than other impregnated samples in the determination of screw retention strength.

Keywords: Open door conditions, Sessile oak, Pine tannin, Acorn, Immersol aqua, Timber care aqua.

1.Introduction

In the chemical structure of wood, there are polymer compounds such as lignin, hemicellulose, cellulose which compose the main parts of the cell wall (Papodepoulos, 2005).
In addition, there are also components in the wood which have lower molecular weight and are called extractives (Gindl & Teischinger, 2003).
It was seen that the air dried and full dried densities of the impregnated samples increase when examined in respect to control samples. This may be due to more penetration of the impregnation solution into the extended wood. As a matter of fact, it was observed that the longer-term immersion process of conservation amount was higher than the short-term immersion process (Atar, 2007).

It has been stated that only a small part of the crusts of the chopped trees are utilized for chemical production (Fengel & Wegener, 1981; Sjöström, 1984).
Tannins constitutes of chemically water-insoluble complexes and phenols which can be water-soluble by binding phenolic hydroxyl groups, which are present in large quantities in the tannin with proteins. The compound formation of tannin, which has different heterogeneous groups, with other molecules depends on the structure of the tannin (degree of polymerisation, molecular weight) (Barahona *et al.*, 1997).
The tendency of tannin to form compounds with proteins depends on protein structure, size and charge (Hagerman & Butler, 1981; Scalbert, 1991).

2. Material and Methods

As a test material, sessile oak (*Quercus petreae L.)* wood was preferred because of its wide usage in woodworking, furniture and decoration works. The lumber, which was used in the preparation of test samples, was obtained from Trabzon timber enterprises by completely random method. In the selection of wood material, the requirements indicated in TS 4176 were followed by taking into consideration that the timber colour is natural, unrecorded, without knots, with smooth fibres, no reaction to wood, not affected by fungus and insect pests.
The pine tannin and acorn were chosen as natural impregnation material which is easy to supply to and also a cheap extractive material. Imersol aqua and timber care aqua were preferred as artificial impregnating materials because they can be applied with dipping method, they give quick results and they are water based and transparent.

PVA-D4 glue resistant to open air conditions and with two components, was used in preparation of experiment samples on bonding resistance parallel to fibres.

Experiment samples were prepared from sessile oak wood in accordance with TS standards in Gumushane University Gumushane Vocational High School Furniture and Decoration Workshop in order to be used in the study for every single test to be kept in outdoor conditions for one year (Table 1).

Table 1. Size and standards of experiment samples.

The name of the test	Size (mm)	Standards
Air Dried Density	20 x 20 x 30	(TS 2472, 1976)
Full Dried Density	20 x 20 x 30	(TS 2472, 1976)
Determination of malformation (Distortion/Twisting)	300 x 200 x 20	(TS EN 1310, 2001)
Determination of Bending Resistance	20 x 20 x 300	(TS 2474, 1976)
Determination of Elastic Modulus	20 x 20 x 300	(TS 2478, 1976)
Determination of Compressive Strength Parallel to Fibres	20 x 20 x 60	(TS 2595,1976)
Determination of bonding Resistance Parallel to Fibres	20 x 15 x 150	(TS EN 205, 2004)
Determination of the screw holding resistance	50 x 50 x 20	(TS EN 13446, 2005)

Primarily, the solution was prepared for the impregnation process by using pine tannin. The solution was prepared by resolving %5 mineral tannin material in demineralized (distilled and in 60-degree heat) water based on the weight amount. The solution and the processing heat were set as 20±2 ˚C for the all impregnations. The specimens, whose dimensions and weight at full wet were determined after the impregnation, were conditioned to relative humidity of 60% ± 3% and equilibrium moisture of 12% at 20 ± 2 ˚C in the conditioning cabinet (ASTM-D 1413-07, 2007).

Experiment samples were dipped in the solution by putting imersol aqua and timber care aqua materials inside 20*50*50 cm sized boxes with the solution, which was prepared by using pine tannin and acorn, and then wire cage weight was put on it. Dipping process was performed for 2 hours.

The samples, which were to be brought to equilibrium humidity after completing impregnation process, were later subjected to open air conditions for 1 year long.

The retention amount (r-kg/m^3) of impregnation material in the experiment samples, were calculated with the help of the equations below before and after impregnation (Table 2), (TS 5724, 1988).

$$R = \left[\frac{G.C}{V} \right] \times 10^3 \ \ \text{kg/m}^3 \qquad (1)$$

Here;

$G = T_2 - T_1$

T_1 = Test sample weight before impregnation (g)

T_2 = Test sample weight after impregnation (g)

V= Sample size (cm^3)

C= Solution concentration (%)

Table 2. Retention amount averages of samples used in the experiment.

Retention Amount (g/m^3)		
Natural Impregnation Material	Pine Tannin	13.88
	Acorn	15.41
Artificial Impregnation Material	İmersol Aqua	3.25
	Timber Care Aqua	3.33

Control and impregnated samples were kept in open air conditions within the Gazi University Technical Education Faculty area in Ankara for 1 year between 01.09.2011 – 01.09.2012 according to the principles specified in ASTM-G7-05 standard. The test samples were placed at an angle of 45 ° to the ground floor with their surfaces facing south.

3. Results and Discussion

According to the variation analysis conducted, it was found that was determined that there were significant differences of 5% between the control, natural impregnated and artificially impregnated samples in experiments of the compressive strength parallel to the fibres and bonding resistance parallel to fibres. It has been stated that there is no significant difference in the determination of air-dry density, determination of full dry density, determination of malformation, determination of bending resistance, determination of elastic modulus, and determination of screw holding resistance in the sessile oak samples impregnated with control pine tannin, timber care aqua and imersol aqua (Table 3).

Table 3. Variance Analysis on physical and mechanical properties of sessile oak.

Test Name	Variation Source	Degree of freedom	Sum of squares	Squares Average	F-Value	Pr>F
Air Dried Density	Between groups	4	0.016	0.004	1.698	0.167
	In groups	45	0.105	0.002		
	Total	49	0.121			
Full Dried Density	Between groups	4	0.130	0.003	1.824	0.141
	In groups	45	0.082	0.002		
	Total	49	0.095			
Determination of malformation	Between groups	4	43.6	10.903	0.837	0.509
	In groups	45	0.105	13.029		
	Total	49	0.121			
Determination of Bending Resistance	Between groups	4	1183.827	295.957	1.444	0.235
	In groups	45	9221.259	204.917		
	Total	49	10405.086			
Determination of Elastic Modulus	Between groups	4	20610832	5152708	1.896	0.128
	In groups	45	122298840	2717752		
	Total	49	142909672			
Determination of Compressive Strength Parallel to Fibres	Between groups	4	141.844	35.461	2.888	0.033*
	In groups	45	552.496	12.278		
	Total	49	694.340			
Adhesion Resistance Parallel to Fibres	Between groups	4	11.404	2.851	2.853	0.034*
	In groups	45	44.974	0.999		
	Total	49	56.378			
Determination of the screw holding resistance	Between groups	4	1462.562	365.641	0.852	0.50
	In groups	45	19309.863	429.108		
	Total	49	20772.425			

* Important at 5% level

The physical and mechanical properties of the sessile oak wood impregnated with natural and artificial impregnated materials are shown in table 4.

Table 4. Values related to physical and mechanical properties of sessile oak wood impregnated with natural and artificial impregnated materials.

Process	Impregnation	X_{ort}	S_x	CV
Air Dried Density (g/cm^3)	Control	0.69	0.05	0.07
	Pine Tannin	0.69	0.06	0.09
	Acorn	0.70	0.04	0.06
	Immersol Aqua	0.70	0.04	0.06
	Timber Care Aqua	0.71	0.07	0.10
Full Dried Density (g/cm^3)	Control	0.66	0.04	0.06
	Pine Tannin	0.67	0.04	0.06
	Acorn	0.68	0.03	0.04
	Immersol Aqua	0.68	0.03	0.04
	Timber Care Aqua	0.67	0.06	0.09
Determination of malformation (mm) (Distortion/Twisting)	Control	10.46	3.50	0.34
	Pine Tannin	8.33	3.20	0.38
	Acorn	10.35	5.74	0.56
	Immersol Aqua	9.08	6.23	0.69
	Timber Care Aqua	9.51	5.19	0.55
Determination of Bending Resistance (N/mm^2)	Control	118.4	16.78	0.14
	Pine Tannin	110.56	12.67	0.12
	Acorn	118.67	17.41	0.15
	Immersol Aqua	115.85	16.49	0.14
	Timber Care Aqua	116.19	16.81	0.15
Determination of Elastic Modulus (N/mm^2)	Control	7516	1698.61	0.17
	Pine Tannin	9585	1257.25	0.13
	Acorn	10783	2141.57	0.20
	Immersol Aqua	10560	1131.01	0.11
	Timber Care Aqua	10589	1507.01	0.14
Determination of Compressive Strength Parallel to Fibres (N/mm^2)	Control	32.75	3.43	0.11
	Pine Tannin	30.43	3.16	0.10
	Acorn	31.52	3.60	0.11
	Immersol Aqua	31.16	3.15	0.10
	Timber Care Aqua	34.44	2.00	0.06
Determination of Bonding Resistance Parallel Towards Fibre (N/mm^2)	Control	6.24	1.64	0.26
	Pine Tannin	4.86	1.02	0.21
	Acorn	5.33	1.62	0.30
	Immersol Aqua	6.23	1.07	0.17
	Timber Care Aqua	3.66	1.12	0.31
Determination of the screw holding resistance (N/mm^2)	Control	381.57	0.05	0.0001
	Pine Tannin	381.23	1.42	0.004
	Acorn	366.50	38.34	0.10
	Immersol Aqua	369.40	27.84	0.08
	Timber Care Aqua	379.16	7.37	0.02

According to Table 5; the highest air dry density change was 0.71 g/cm^3 in samples impregnated with timber care aqua, one of artificial impregnation materials. While the mean values of the air-dry density change were found to be 0.69 g/cm^3 in samples impregnated with pine tannin, one of natural impregnation materials, values were identified as 0, 70 g/cm^3 in samples impregnated with acorn. The full dry density change was determined to be 0.68 g/cm^3 in the samples that were impregnated with the highest acorn and immersol aqua.

While the average deformation values of the samples impregnated with the control, natural and artificial impregnation materials left to the outdoor conditions for one year was determined to be highest as 10.46 mm in the control samples, the least deformation were found to be 8,33 mm in the samples impregnated with pine tannin (Table 4).

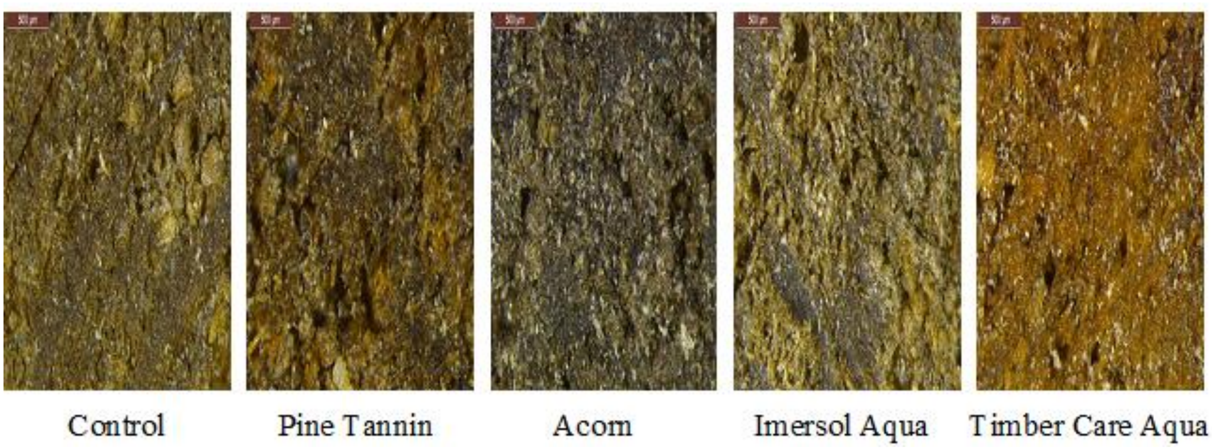
The lowest average values in the determination of bending resistance were lowest with 10.56 N/mm^2 in the samples impregnated with pine tannin while the highest values were found to be 118.67 N/mm^2 in samples impregnated with acorn, one of natural impregnated materials. In determination of the elastic modulus, the lowest averages values were identified to be 7516 N/mm^2 in the control samples (Table 4).

The highest average value of the comprehensive strenght parallel to fibres was determined as 34.44 N/mm^2 in samples impregnated with timber care aqua, one of artificial impregnation material, while the lowest average value was found to be 30.43 N/mm^2 in samples impregnated with pine tannin, one of natural impregnation materials (Table 4).

The lowest average value for the bonding resistance parallel to fibres was determined to be 3,66 N/mm^2 in the samples impregnated with timber care aqua, one of artificial impregnation materials, while the highest average value was found to be 6.24 N/mm^2 in the control samples (Table 4).

The highest screw holding resistance average value was found to be 381.57 N/mm^2 in the control samples, while the lowest average value was found to be 366.40 N/mm^2 in the samples impregnated with acorn, one of natural impregnation material (Table 4).

Microscopic views of the specimens taken from the parts exposed to open-air conditions for one year (impregnated material) are given in Picture 1, (Yasar, 2014).



Picture 1. Microscopic views of the specimens after a year exposure outdoor conditions (control, pine tannin, acorn, imersol aqua, timber care aqua).

4.Conclusions

It was seen that close values were gotten when control samples and impregnated samples of air dried density and full dried density changes are compared. The full dried density values of the impregnated samples were higher than the control samples. It was determined that the obtained air-dried density and full dried density values were close to those of Bozkurt's study

(Bozkurt, 1982). It was reported that whether amount of air dried density was low or high depends on the different materials used.

It was determined that the average deformation values of the samples impregnated with control, natural and artificial impregnation materials left to the outdoor conditions for one year were highest in the control samples while the lowest distortion/twisting value was in the samples impregnated with pine tannin.

In determination of bending resistance and elastic modulus, the highest values were found in the samples impregnated with acorn, one of natural impregnation materials.

While in determination of compressive strength parallel to fibres the values of samples impregnated with timber care aqua were higher than control samples, the mean values obtained from the other impregnated samples were found lower when compared with control samples.

In the determination of bonding resistance parallel to fibres, a higher mean value was obtained for the non-impregnated control samples when compared with the samples impregnated with the natural and artificial impregnate materials.

In determination of screw holding resistance the average values obtained from samples impregnated with natural and artificial impregnated materials were lower in comparison with non-impregnated control samples values.

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