DETERMINATION OF THE EFFECTS OF WOOD TYPES AND IMPREGNATION PROCESS IN PERFORMANCE OF THE WINDOW FRAMES CORNER JOINTS

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ABSTRACT

This study examines the effects of wood types and impregnation (procedure types and process time) in performance of window frames corner joint with double tenon. For this purpose, "L corner joint" type samples (number 120) were manufactured by using Scotch pine (*Pinus sylvestris* Lipsky), oak (*Quercus petreaea* Lipsky) and black locust (*Robinia pseudoacacia* L.). Polyvinyl acetate based (two kompenant-D4) adhesive were used to bond tenon and mortise corner joints. The samples were impregnated by using the method of immersion for 20 and 40 min with mixture of wax / linseed oil (3 % paraffin, 10 % linseed oil, 87 % white spirit) and imersol aqua. The diagonal compression test was applied to test samples (determine performance of the window frames corner joint) according to ASTM-D 143–83 1983 standards.

Finally, the highest diagonal compression performance was obtained on black locust samples (7480.016 N) with the immersol aqua impregnated for 40 min. The lowest diagonal compression performance was received on oak samples (2572.706 N) which were impregnated in white mixture of wax / linseed oil for 40 min.

KEYWORDS: Paraffin, Imersol aqua, performance, diagonal pressure, diagonal strength, window frames, corner joint, tenon and mortise.

INTRODUCTION

Wood and wood products are classified as traditional materials. Nowadays, wood and wood products, they are used as a solid material after having been passed through various processes, and as products obtained from wood. Wood is used especially in building floors, wall, covering works, and commonly in roofs, molds, scaffolds. Recently, wood has started to be used directly in construction of wooden buildings by impregnation through several techniques and chemicals. With all of the above, in structures wood is, mostly used in construction of door and window frames. Corners are joined by using different techniques in order to manufacture frames of doors and windows. These corner joints are subjected to their own weights and loads consisted of external influences (open air condition, glue type, impregnation process) (Tokgöz et al. 2005).

Bonding strength was investigated on samples of window frames which were manufactured from soft wood types lamella (3 layers) and glued with PVA. The samples were immersed in the external environment for a period of 16 months and hardness test and adhesion test were applied on the corner joints of the samples. When the adhesive lines of corner joints were opened different amounts determined (Turkulın 1993).

Types of transverse, longitudinal, corner connections which are used in wooden window and furniture, were analyzed and classified according market needs/market requirements, material consumption, tensile and rotation strength of them. In the study, field of use of combination types and production patterns were specified and also rigid combinations were addressed. (Kurtoğlu et al. 1993).

According to a research named "The characteristics of the laminated windows that are made of various pine species" when glued with PVAc of pine containing 15 to 2 % resin, a gap occurs in the glue joints because of its resin and it was determined that the adhesive strength decreases resin, does not affect PUR glue and the strength of the combinations remains the same (Bröker et al. 1994).

There is a previous study reporting that the values of the tensile strength of the chestnut (0.5467 N.mm⁻²) and poplar wood (0.5620 N.mm⁻²) under pressure are not statistically different. But it was seen the chestnut has a better strength (1.1009 N.mm⁻²) than poplar wood (Gökdemir and Yıldız 2001).

Scots pine is bonded with beech and oak prepared from simple threaded plug, 5 threaded plug, threaded plug, and wedge-wood frame corner samples of polyoctanevynyl combination of glue, urea formaldehyde and phenol formaldehyde glue, and the bending strengths of combinations of these constructions were investigated by considering wood and glue species. Height, width and thickness of combination samples were taken as 25, 4.2, and 3.3 cm respectively and the stiffness of the combination has been measured by applying opposite forces to both elements of the samples. According to the results of the experiments, it was determined that five toothed combination of joggle has the highest resistance and combination while the simple joggle has the lowest resistance. (Can 2007).

Uzer, in his study, examined the compression and tensile strengths by combining, at the specific humidity level (u=12 %), barefaced mortise and tenon, stub mortise and tenon, haunched stub mortise and tenon, three species of wood timber (pine, chestnut, fir) and held an experiment by a group on this. According to the experiments held, average tensile strength is found as follows: stub mortise and tenon (pine: 73.5 kg, chestnut: 64 kg, fir: 42.5 kg), haunched stub mortise

and tenon (pine: 64,5 kg, chestnut: 57.5 kg, fir: 38 kg), and finally even barefaced mortise and tenon (pine: 59 kg, chestnut: 52.5 kg, fir: 35.5 kg) and it was determined that there are not much differences between the shapes of combinations in terms of average compressive strength. They were identified as: haunched stub mortise and tenon (pine: 27.5 kg, chestnut: 24 kg, fir: 17.5 kg), barefaced mortise and tenon (pine: 27.1 kg, chestnut: 22.5 kg, fir: 20.5 kg), stub mortise and tenon (pine: 26 kg, chestnut: 25 kg, fir: 17 kg). (Üzer 1999).

Another study on "The effects of tree species, glue type and direction of the pressing on the diagonal tensile performance at single-tongued and double-tongued wood corner combinations" reports that diagonal tensile performance was obtained from the samples of D4 glue pressed over the edge with double-tongued pine. It was indicated that the lowest diagonal tensile performance was obtained from the samples of edge pressed Kleiberit glued single tongued fir. (Altınok et al. 2009).

Forces of the smooth tongued, smooth tongued dowel, secret tongued, dowel with secrettongued corner joints, manufactured them Scotch pine, fir, chestnut and Taurus divan and against the tensile strength were investigated. As a result of the tests, it was observed that the largest tensile strength is found in the pine material at smooth tongued merge and the lowest tensile strength is found at the smooth tongued merge when chestnuts are used (Tokgöz 2005). At the Wooden window wings' upper and lower corner tongued joints, in terms of data of tensile strength and sag, it was found that joints with dowel give better results than the joints without dowel (Arslan et al. 2006).

It was determined that paraffin, wood and wood-based panel products reduced the water uptake (Yıldız 1988, Var et al. 1997, 2000).

In a study relating to various combinations that are applied to the poplar material samples, considering the strength of combination's effect on the lowering cost of production in terms of economic importance, a suitable mass production design was proposed. Combining multi-tongued and finger corner combinations which consist of push and pull elements are 2 or 4 times more resistant than joints with dowel that is in the same manner (Richards 1962). At tongued joints, surface pressing method provides a stronger link than traditional edge pressing method (Willard 1966).

This study aims to determine effects of wood types and impregnation (procedure types and process time) in performance of the window frames corner joints with double tenon - mortise.

MATERIAL AND METHODS

Wood

In all samples of experimental studies, Scots pine (*Pinus sylvestris* Lipsky), sessile oak (*Quercus petraea* L.) and black locust (*Robinia pseudoacacia* L.) woods were used. Wood materials were taken through the random selection method. Wood was considered to have natural color, unaffected fungi or insects, be clean, do not have growth defects, smooth fiber, and alive. Some technical characteristics of wood types used in the experiments are given in Tab. 1.

Impregnation process

Imersol aqua (from HEMEL-HICKSON Timber Products Ltd. Istanbul) and paraffin wax with a melt point 56°C were used as wood preservatives while white spirit was used as organic solvent in this study. Imersol aqua is a non-flammable, odourless, fluent water based, completely soluble in water, noncorrosive material with a pH value of 7 and a density of 1.03 g.cm⁻³. It is available as a ready-made solution. It contains 0.5 % w/w tebuconazole, 0.5 % w/w propiconazole,

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Tab. 1: Selected technical characteristics of wood types that are used in the experiments (Bozkurt and Göker 1987).

Wood types	Ovendry gravity (g.cm ⁻³)	Air-dry gravity (g.cm ⁻³)	Bending strenght (u =12 %) (kg.cm ⁻²)	Compression strength (//,u =12 %) (kg.cm ⁻²)	
Scots pine	0.496	0.52	648.7	379.2	
Sessile oak	0.675	0.69	1185.0	606.0	
Black locust	0.720	0.76	1361.0	730.0	

1 % w/w 3-iodo-2-propyl-butyl carbonate and 0.5 % w/w cypermethrin. 3 % concentration paraffin solution (3 % paraffin, 10 % linseed oil, white spirit 87 %) was prepared as the other impregnation material according to w/w basis (Yıldız and Hafızoğlu 1990). After being immersed in a solution of imersol aqua and paraffin for 20 and 40 minutes, test sample was impregnated according to ASTM D 1413–99 2005 and producers' specifications. Samples were removed from the solution and dried with paper towel at the end of each period. Impregnated samples were kept for nearly two weeks at the laboratory conditions (Voulgaridis 1986), after that they were dried again in an oven at 56°C until the weight does not change (paraffin melts at 56°C and subjects to material loss at higher temperatures), were cooled in a desiccator and then weighed. Thus the impregnated ratio in each sample was calculated by the following formula.

NPM = ((Ms -Mo)/Mo) x100

where: NPM - ratio of impregnation (%), Ms - ovendry weight after impregnation (g), Mo - ovendry weight before impregnation (g).

Glue

The elements of "L" type test samples are glued with polyvinyl acetate based (two component-D4) adhesive which is enhanced by the addition of 5 % hardener (Turbo hardener 303.5). According to BS EN 204 1991 standards, it is marketed as ready for use for D3 class of service as one component. Specific properties of the adhesive are as follows: Viscosity; 13000 \pm 2000 MPa s (1300 \pm 2000 cps), density; component A 1100 kg.m⁻³ component B (Hardener) 1130 kg.m⁻³, moisture content for gluing; 10 % \geq , adhesive unilaterally; 180–200 g.m⁻², compaction pressure; 1.2 N.mm⁻², pres temperature: 80°C, press time; 20 min., final bonding strength time; 12 h \geq (Söğütlü and Döngel 2007, Örs et al. 1999).

Preparation of test samples

In this study, diagonal compression test samples were prepared according to the following procedure where:

- three wood types (Scots pine sessile oak black locust),
- two impregnation material (imersol aqua paraffin),
- two process time (20 min. 40 min.),
- ten in each case and total 120 (3x2x2x10) double tongued (Fig. 1).

For this purpose, draft elements of "L" type corner joint samples were impregnated above, after then they were dried naturally by cutting in as rough draft and putting nearby near to ventilate and in an environment that does not get direct sunlight.



Fig. 1: Diagonal compression test samples.

After that, drafts were kept in an air conditioning closet set at $20 \pm 2^{\circ}$ C temperature and at 65 ± 5 % relative humidity conditions until it reaches to the equilibrium 12 % moisture content. Having been cut in clear dimensions, tenon and mortise were opened on the edge of samples by the milling machine. The elements of samples were joined by glue according to the 180 g.m⁻² account which tenon and mortise were opened. Glue line of corner joint of pressed samples was left to be fully hardened. Surfaces of experimental samples were pressured in the same ratio according to industrial applications. After taking the coupling gap for each sample returning in equal numbers, the equal pressure was applied by using hooks in the compression pressure.

Method

Tests were applied by 4 tons capacity of Universal Testing Device at 800 kp stage according to ASTM-D 143–83 1983 standards. Rate of progress of the experimental device was set to receive 2 mm distance in a minute. Maximum forces were recorded (N).

L-type samples and grooved opening lines of glue joints are usually observed during the experiments. There were no refractive elements like corner joints. Leaving only the layers of glue in the form of tongue and groove joints were opened. Wood did not emerge as a rupture that easily extracts portions.

Evaluation of data

In order to determine the effects of window frames in the corner joints, wood types, impregnation materials and process time analyses of variance were performed. Sources of variance of interactions are meaningful according to $\alpha = 0.05$, factors of which are important for the differences determined by the Duncan test.

RESULTS AND DISCUSSION

The amount of net impregnation that was obtained by using 20 and 40 minutes immersion method is given in Tab. 2.

When the amount of net impregnation obtained in experimental samples is examined, it is observed that the longer the immersion time (40 min.) is the more amount of impregnation the test samples contain. After 40 min. process time 1 - 8 % of the amount of net impregnation, which is more than after a 20 min. process time.

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	Scots pine		Black	locust	Sessile oak		
	Imersol aqua	Paraffin linseed oil	Imersol aqua	Paraffin linseed oil	Merua	Merua Paraffin linseed oil	
20 min.	0.402	0.372	0.730	0.723	0.614	0.610	
40 min.	0.406	0.402	0.742	0.75	651	0.657	

Tab. 2: The amount of net impregnation obtained in experimental samples (%).

Applying the multiple analyses of variance to the average performance of diagonal compression that is obtained at the window frames in the corner joints, according to the wood type, impregnation materials and the process time, changes in results are given in Tab. 3.

Tab. 3: Analysis of variance to the results of diagonal compression performance.

Variance source	Sum of squares	S.D.	Mean squares	F value	P ≤ 0.05
Wood type	65511241.254	2	32755620.627	710.859	0.000
Process time	338272.942	1	338272.942	30.06.41	0.009
Impregnation materials	131776505.656	1	131776505.656	2859.798	0.000
Wood type x Process time	2372632.980	2	1186316.490	25.745	0.000
Wood type x Impregnation materials	38325518.591	2	19162759.295	415.868	0.000
Process time x Impregnation materials	1992149.306	1	1992149.306	43.233	0.000
Wood type x Process time x Impregnation materials	660249.412	2	330124.706	30.06.64	0.002
Error	2764736.919	120	46078.949		
Total	2457807854.181	75			

According to the results of analysis of variance of wood types, impregnation materials and process time, and their binary comparisons in terms of diagonal pressure performance and with the α =0.000 significance level it is seen that they are different. And in order to define the differences at α =0.05 level, the Duncan test is applied. The results of the least significant difference (LSD) tests that have meaningful wood type interactions are given in Tab. 4.

Letter (A) indicates the most successful result in the Homogeneity groups. According to the factors of wood type, the highest average value of diagonal compression performance is at black locust (6022.435 N), and the lowest is at scots pine (4068.462 N). Black locust carries 48 % higher force than pine and 7 % higher than oak. The results of the LSD tests that have meaningful processes time are given in Tab. 5.

Tab. 4: The comparison results of the average diagonal compression performance according to wood types (N).

Wood types	χ	HG
Black locust	6022.435	А
Scots pine	4068.462	С
Sessile oak	5701.487	В

LSD: 255.45, χ : mean HG: Homogeneous group

Tab. 5: The comparison results of the average diagonal compression performance according to the process time (N).

Process time	χ	HG	
20 min	4528.263	В	
40 min	4678.435	А	

LSD: 268.170, χ : mean HG: Homogeneous group

According to the factors of process time, the highest average value of diagonal compression performance was obtained at 40 min. impregnated paraffin process term (4678.435 N), the lowest was obtained at 20 min. From the experimental samples, results of the LSD tests that have meaningful types of procedure are given in Tab. 6.

Tab. 6: The comparison results of the average diagonal compression performance according to procedure type (N).

Procedure type	χ	HG	
Control	7907.243	А	
Imersol aqua	6085.33	В	
Paraffin linseed oil	3121.366	С	

LSD: 217.18, χ : mean HG: Homogeneous group

According to procedure type, the highest average value of diagonal compression performance was obtained on control samples (7907.243 N) and on Imersol aqua (6085.333 N) from the experimental samples. The lowest average value of diagonal compression performance was obtained on paraffin linseed oil samples (3121.366 N).

Results of the LSD tests that have meaningful procedure type, process time and interaction of wood types are given in Tab. 7.

According to the impregnation material, process time, wood types and their interaction, black locust has the highest average performance of the diagonal compression with impregnated Imersol aqua by 40 min process time (7480.016 N). The lowest is on the same wood type with impregnated linseed oil paraffin-term by 40 min process time (2572.706 N) and sessile oak with impregnated linseed oil paraffin-term by 20 min process time (2688.418 N) were obtained from experimental samples (Fig. 2).

It was determined at approximately 23 % in samples with impregnated aqua immersion and 60 % in samples with impregnated paraffin linseed oil according to the performance degradation control samples. Paraffin linseed oil displayed a higher reduction in performance because it contains fatty substances impregnated samples. This result is supported with the source studies held by Yıldız 1988, Var et al. 1997, 2000.

In impregnation performed by dipping method, 20 minutes and 40 minutes options were applied as process times. By increasing process time from 20 min to 40 min, approximately 10 % increase was obtained in performance. An increase in process time on the basis of impregnation material occurred; while providing 9 % increase of performance in impregnation by imersol aqua and 7 % reduction of performance in impregnation by paraffin linseed oil resulted. Increase in process time on wooden type basis; while providing 7 % increase in performance on pine, 13 % on oak, resulted in 7 % performance of degradation on *Robinia*. These results are consistent with the source studies held by Bröker et al. (1994).

When wood material is left unprotected, it is easily degraded under the influence of invasive

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Tab. 7: The comparison results of the average diagonal compression performance according to impregnation material, process time and interaction of wood types.

D	Types	Black locust		Scots pine		Sessile oak	
Process time	impregnation	χ	HG	χ	HG	χ	HG
20 min.	Imersol aqua	7211.332	BC	3808.648	G	6464.114	D
	Paraffin linseed oil	3596.350	GH	3400.718	HI	2688.418	J
40 min.	Imersol aqua	7480.016	В	4358.126	F	7189.760	С
	Paraffin linseed oil	2572.706	J	3341.886	HI	3128.116	Ι
Control		9251.770	А	5432.934	Е	9037.026	А

LSD: 371. 811, x: mean HG: Homogeneous group



Fig. 2: Procedure type, process time and interaction of wood types.

external environment and this results in non compensative damages or it can be repaired at high costs. For this reason, in order to avoid degradation in unprotected wood, it has become compulsory to protect it with various protective substances.

CONCLUSIONS

This study determines the effect of impregnation of Imersol aqua and paraffin linseed oil on the performance of diagonal compression on glued elements of samples after performing impregnation. Wood preservatives slightly decreased the bonding strength of glue. For this reason a reduction was seen on the experimental samples that were represented in window frames.

Similar studies in literature in the same tree species by dualism with the performance data obtained the observed double - tongue and groove. Deformation of the test samples during the experiments is usually in the form of breakage which occurred from the bottom of mortises in double-tongued. This application of double tenon mortise remain in thickness may be due to weaker than that of uniqueness. On the double tongue and groove examples, the mortise to be equal to the thickness of the tenon into a single carrier, a higher stress was reported (Altinok et al. 2009).

Because of the process time of 40 min provided only 4–5 % increases of performance, 20 min. in dip impregnation may be preferred. The process time of 20 min. may be preferred as priority

in terms of time savings in production. Because the locust wood is not produced widely, Oak is suggested primarily, and then Yellow pine, instead of *Robinia*.

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