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Effects of impregnation with Imersol-AQUA on the bending strength of some wood materials

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ABSTRACT

The aim of this study was to investigate the impacts of impregnation with Imersol-Aqua on the bending strength of some solid wood materials. For this aim, Oriental beech (*Fagus orientalis* Lipsky), oak (*Quercus petrea* Liebl.), scotch pine (*Pinus sylvestris* Lipsky), Uludağ fir (*Abies Bornmülleriana* Lipsky), Oriental spruce (*Picea orientalis* Lipsky) and poplar (*Populus nigra* Lipsky) wood samples were prepared according to TS EN 408 and impregnated with Imersol-Aqua by the method of short-, medium- and long-term dipping according to ASTM D 1413 and producers' definition. After the impregnation process, bending strength was measured according to TS EN 408. Consequently, among the non-impregnated wood samples, the bending strength was found to be the highest in Oriental beech, (138.617 N mm^{-2}) and the lowest in poplar (61.021 N mm^{-2}). As for the period of dipping, the highest bending strength was obtained in short-term dipping and the lowest in long-term dipping. Considering the interaction of wood type and the period of impregnation, the highest bending strength was obtained in Oriental beech with short-term dipping (118.404 N mm^{-2}) whereas the lowest was in poplar with long-term dipping (53.510 N mm^{-2}). In consequence, in massive constructions and furniture elements that where bending strength after the impregnation is of great concern, short-term impregnation of Oriental beech and scotch pine wood materials could be recommended.

1. Introduction

If the wood materials are used without processing by preventive 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 [2]. In case wood is not impregnated but only painted and varnished instead, the prevention on the surfaces is limited to a maximum of 2 years [3].

It is reported that, in mines, as a result of the impregnation of the beech and spruce wood with water-soluble salts, the bending, tensile and impact strength decreased a little whereas compression strength increased [4]. 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% [5].

In the impregnation of pine and beech wood with UA salts and tar oil, the tar oil increased compression strength by 10% and UA salts increased with a small rate. On the other hand, the tar oil increased the bending strength whereas the UA salts diminished the bending strength [6].

Among the materials used for the impregnation of pine; sodium pentaclorfenet, copper sulphate and sodium fluoride increased the compression strength respectively by 95%, 25% and 3%, whereas zinc chloride decreased the compression strength by 9%. Sodium pentaclorfenet also increased the bending strength [7]. In another study, pressure treatment caused a decrease of 8–10% in the bending strength of different wood types [8].

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% [9]. In another study, chromate copper arsenate (CCA) and arsenate copper arsenate (ACA) salts did not cause any significant impact on the modulus of elasticity in bending [10]. After the impregnation of pine wood samples by hot-cold open tank method with 11 preventives, no significant difference was observed in the bending strength except the decreasing effects of fluotox containing acid florid [11].

In this study, Oriental beech (*Fagus orientalis* Lipsky), oak (*Quercus petrea* Liebl.), scotch pine (*Pinus sylvestris* Lipsky), Uludağ fir (*Abies Bornmülleriana* Lipsky), Oriental spruce (*Picea orientalis* Lipsky) and poplar (*Populus nigra* Lipsky) woods commonly being used in furniture manufacturing were examined with respect to the effects of impregnation with Imersol-Aqua on bending strength.

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2. Experimental

2.1. Wood materials

The woods to be used as test samples were randomly selected from the timber merchants of Ankara. Specific pains were taken for the selection of wood materials. Accordingly, non-deficient, proper, knotless, normally grown (without zone line, without reaction wood and without decay, insect mushroom damages) wood materials were selected.

2.2. Impregnation material

Imersol-Aqua used as an impregnation material in this study was supplied from HEMEL, Istanbul. Imersol-Aqua is 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 ready-made solution. It contains 0.5% w/w tebuconazole, 0.5% w/w propiconazole, 1% w/w 3-iodo-2-propynl-butyl carbonate and 0.5% w/w cypermethrin. Before the application of Imersol-Aqua on the wood material, all kinds of drilling, cutting, turning and milling operations should be completed and the relative humidity should be in equilibrium with the test environment. In the impregnation process, dipping duration should be at least 6 min and the impregnation pool must contain at least 15 l of impregnation material for 1 m^3 of wood [12].

2.3. Determination of density

The densities of wood materials, used for the preparation of test samples were determined according to TS 2472 [13]. For determining the air-dry density, the test samples with a dimension of 20 × 30 × 30 mm were kept under the conditions of 20 ± 2 °C and 65 ± 5% relative humidity until they reached a stable weight. The weights were measured with an analytical scale of ±0.01 g sensitivity. Afterwards, the dimensions were measured with a digital compass of ±0.01 mm. The air-dried densities (δ_{12}) of the samples were calculated with the following equation:

$$\delta_{12} = \frac{W_{12}}{V_{12}}\ \mathrm{g\ cm^{-3}} \tag{1}$$

where W_{12} is the air-dry weight (g) and V_{12} is the volume (cm^3) at air-dry conditions.

The samples were kept at a temperature of 103 ± 2 °C in the drying oven until they reached a stable weight for the assessment of full-dry density. Afterwards, full-dried samples were cooled in the dessicator containing (phosphorus pentoxide) P_2O_5. Then, they were weighted on a scale of ±0.01 g sensitivity and their dimensions were measured with a compass of ±0.01 mm sensitivity. The volumes of the samples were determined by stereo metric method and the densities (δ_o) were calculated with the following equation:

$$\delta_o = \frac{W_o}{V_o}\ \mathrm{g\ cm^{-3}} \tag{2}$$

where W_o is the full-dry weight (g) and V_o is the full-dry volume (cm^3) of the wood material.

2.4. Determination of humidity

The humidity of test samples before and after the impregnation process was determined according to TS 2471 [14]. Thus, the samples with a dimension of 20 × 20 × 20 mm were weighed and then oven dried at 103 ± 2 °C till they reached a constant weight. Then, the samples were cooled in a dessicator containing (phosphorus pentoxide) P_2O_5 and weighed with an analytical scale of 0.01 g sensitivity. The humidity of the samples (h) was calculated with the following equation:

$$h = \frac{W_r - W_o}{W_o} \times 100 \tag{3}$$

where W_r is the initial weight of the samples (g) and W_o is the final dry weight (oven-dry) of the samples (g).

2.5. Preparation of experimental 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 °C and 65 ± 3% relative humidity for 3 months until reaching an equilibrium in humidity distribution. The samples with a dimension of 20 × 20 × 400 mm were cut from the drafts having an average humidity of 12% according to TS EN 408 [15]. The densities and humidity values of all test samples were measured before the impregnation process.

The test samples were impregnated according to ASTM D 1413 [16], TS 344 [17] and TS 345 [18]. The samples were dipped in the impregnation pool immersing 1 cm below the upper surface for 10 min in short-term dipping, 2 h for medium-term dipping and 5 days for long-term dipping [19]. The specifications of the impregnation solution were determined before and after the process.

The processes were carried out at 20 ± 2 °C [20]. Retention of impregnation material (R) was calculated by using the following equation:

$$R = \frac{G \cdot C}{V} 10^3\ \mathrm{kg\ m^{-3}} \quad G = T_2 - T_1 \tag{4}$$

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 °C and 65 ± 3% relative humidity until they reach a stable weight.

2.6. Application of experiment

The tests for bending strength were carried out with the Universal Testing Equipment shown in Fig. 1, according to TS EN 408.

The capacity of the Universal Testing Equipment was 400 N. The speed of the test machine was adjusted to 5 mm/min for breakage to occur in 1–2 min.

Bending strength was calculated with the following equation:

$$\sigma_e = \frac{3F_{max} \cdot (L - l_1)}{2bh^2}\ (\mathrm{N\ mm^{-2}}) \tag{5}$$

where, F_{max} is the breaking load on the scale (N), L is the distance between the lower tension rods (mm), l_1 is distance between two loads (mm), b is the cross-sectional width of the test sample (mm), h is the cross-sectional thickness of the test sample (mm).

2.7. Data analyses

A total of 24 treatment groups were obtained with six different kinds of wood materials, three different impregnation dipping methods and one control sample. Eleven replications were made in each treatment group. Thus, a total of 264 samples (6 × 4 × 11) were prepared. The effects of wood material and impregnation method on the bending strength were analysed by analysis of variance (ANOVA). Duncan's multiple range test was also applied where appropriate.

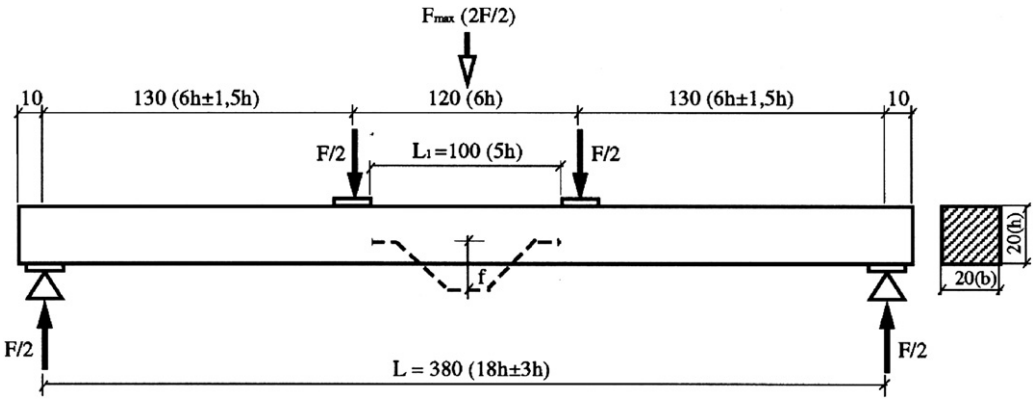

Fig. 1. Test equipment for bending strength (dimensions in mm).