The effect of sodium chloride treatment on bending strength of silver fir wood (*Abies alba* Mill.)

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ABSTRACT

Among properties which characterize the application of silver fir wood (*Abies alba* Mill.) in buildings is its static bending strength. In the framework of improvement of this mechanical property, a comparative experimental investigation was performed with sodium chloride (NaCl) treated and non-treated silver fir wood with regard to modulus of rupture and modulus of elasticity, based on mechanical tests performed according to norms ISO 3133 and 3349.

From 48 samples with dimensions 20x20x300 mm, 24 of them were full covered with solid NaCl for a period of 60 days. The samples were sawn from boards produced from fir logs of the area of Librazhdi, in central Albania. After weight percent gain was calculated, the treated and non treated samples were conditioned and tested by means of mechanical testing machine, in the Faculty of Forestry Sciences of Tirana.

The weight percent gain of treated wood resulted 9.56%. The static bending strength of non treated fir resulted 81 N/mm^2, while for treated wood 16.32% higher. With regard to modulus of elasticity treated wood presented a value equal to 12493 N/mm^2, 8.83% higher than non treated wood.

In the framework of a quantitative and qualitative analysis, measured values of the rupture and elasticity modulus in static bending of non treated wood were compared with respective values of fir wood from the literature. No significant variations were noted.

Although the complexity of factors that affect on the performance of wooden construction, NaCl treated fir wood appears to bring more security for use in buildings.

Key words: *wood, static bending strength, building.*

INTRODUCTION

From many centuries wood is used as raw material for construction and carpentry. This is due to its availability, its renewable and environmentally nature as well as easy processing with low energy requirement. In an effort to improve its performance, wood has been modified and treated in many different ways. Some of the treatments that have been studied are still in the experimental stage, but many others have been applied. Successful procedures or near the success that can be used to improve wood performance, have been listed dozens of years ago. There are known four main categories of wood modifications, chemical, thermal, surface and impregnation modifications. Unfortunately, most of techniques can not improve all the properties of wood. Some properties become short of after treatment.

One of chemical treatment, formaldehydesation, has been recognized for a long time. It is known as a method with high anti-shrinkage efficiency and gives a small increase in weight of the timber. The process consists in heating the timber in the presence of formaldehyde vapors and a catalyst (mineral acid). By the other side, formaldehydesation is related with negative effects, such as significant reduction of friction and tensile strength [1].

Another well-known chemical treatment, acetylating, has been industrially applied since 1961 in boards used in buildings [2]. According to results regarding to pine wood, is noted that acetyl treatment increases more than 55% the dimensional stability of wood, but reduces about 50% its tensile modulus [3]. It is found that Anti Shrinkage Efficiency (ASE) of acetyl treated pine, spruce, birch and beech arrive from 45 to 50%, and the modules of elasticity (MOE) and rupture (MOR) are reduced about 15% [4]. Other studies show that Brinell hardness of acetylated pine is increased up to 20%, but Janka hardness is not significantly affected [5, 6]. This treatment improves wood's resistance against biodegradation and color changes, but reduces some of wood's technological properties (ability of gluing) [7-10].

The chemical treatment of wood with polymeric agents intends to fill the timber with substances that do not dissolve in water. The products show significant improvements in dimensional stability, but after a certain time some mechanical properties will be reduce [1].

Thermal treatment of wood is by far the most advanced commercially in comparison with all various wood modification processes that have been studied. During this process wood is heated under controlled conditions, increasing its dimensional stability [11]. There is always a reduction in mechanical properties, especially of tensile and shear strength in radial and tangential directions, up to 40% [12]. Static bending strength is reduced significantly, but there is no a significant effect on the modulus of elasticity [13, 14].

Almost all modifications and treatments are expensive and present human health and environmental issues. Wood treatment has to represent a process that improves wood properties, but in the same time the material produced, at the end of its life cycle must not present environmental issues greater than those associated with the disposal of untreated wood. Although wood treatment has been the subject of many studies for many years, there are many other methods which have to be taken into consideration with regard to improvement of wood performance during its application.

Actually, silver fir (*Abies alba* Mill.) is one of the most wood species used for load bearing structures. Among properties which characterize its application in buildings is its static bending strength. In the framework of improvement of this mechanical property, as well as to find more economical and more environmental methods for wood treatment, a study was performed to assess the effect of sodium chloride (NaCl) treatment of silver fir wood. The study was focused on modulus of rupture (MOR) and modulus of elasticity (MOE) during static bending process.

MATERIALS AND METHOD

The study was based on comparative experimental investigation, cause-consequence [15]. The method consisted to quantity evaluation of a specific phenomenon caused by a provocative factor and after that, the evaluation of the same phenomenon in the situation of the factor's absence. In our case, the phenomenon was the static bending strength of silver fir wood, and the provocative factor was the sodium chloride treatment of the sample.

Wood material for production of samples was selected from pieces of kiln dried boards without deformations or structure defects, which could influence on bending strength. The boards were sawn from silver fir logs from the area of Librazhdi region, located in central Albania.

There were produced 48 bending strength samples with dimensions 20×20×300 mm, according to the standards ISO 3133 and ISO 3149 [16, 17]. 24 of them were full covered with solid NaCl for a period of 60 days.

Together with samples selected for NaCl treatment, silver fir blocks from the same wood material, with dimensions 20×20×50 mm were covered, too. Before covering, blocks were oven dried in temperature 103ºC ± 1ºC, until they reached equilibrium state, corresponding to 0% moisture content and were weighed. The same procedure was repeated after 60 days and the Weight Percent Gain (WPG) was calculated.

The bending samples were conditioned to reach equilibrium moisture content around to 12%, and were tested by means of mechanical testing machine (Controlab, FRANCE) in the Faculty of Forestry Sciences of Tirana. Bending strength (MOR) and modulus of elasticity (MOE) of NaCl treated and non-treated samples were calculated in N/mm^2, according to standards ISO 3133 and ISO 3349 as follows:

$$MOR = \frac{3P_{\max} \times l}{2bh^2} \tag{1}$$

$$MOE = \frac{l^3 \times \Delta P}{4bh^3 \times \Delta y} \tag{2}$$

where P_{max} was the breaking load in newton (N), l was the distance between the centers of supports in millimeters (mm), b was the breadth of the test piece in (mm), h was the height of the test piece in (mm), ΔP was the difference between respective loads of two points selected on the linear section of load-deformation graphic in (N), and Δy was the relative increment of deflections in bending in (mm).

After testing, the density of wood was measured according to the standard ISO 3131, using pieces provided by destroyed untreated samples [18].

RESULTS AND DISCUSSIONS

Mean values of weight percent gain (WPG), bending strength (MOR) and modulus of elasticity (MOE), together with respective standard deviations, measured in static bending tests are shown in Table 1.

Table 1 Results of weight gain (WPG), bending strength (MOR) and modulus of elasticity (MOE)

Samples	Weight gain [%]	Stand. Dev.	MOR [N/mm^2]	Stand. Dev.	MOE [N/mm^2]	Stand. Dev.
Untreated	0	-	81.01	12.03	11479.67	2837.23
NaCl treated	9.56	0.48	94.22	13.64	12493.32	3778.14

Mean value of the density of untreated silver fir wood used in our study resulted 0.40 g/cm^3, with a standard deviation 0.059. The weight percent gain of treated wood resulted 9.56%.

The static bending strength of non treated fir resulted 81 N/mm^2, while for treated wood 16.32% higher. On the first sight MOR values appeared to be at the same level referring to data reported by literature [19]. From examination of results can be noted that bending strength was influenced considerably by the treatment with NaCl. With regard to increment of density, which resulted 10% after treatment, the increment of bending strength with 16.32% appeared to be a pin pointing remark. Anyway, such increment of density was a negative factor with regard to applications of silver fir wood in constructions. Such value was thought to be caused by the method’s treatment applied. During analyses of the humidity of treated samples was noted that the salt was located only to peripheral substrates of samples. The full covering method applied did not make possible the control of the quantity of NaCl penetrated in the wood. Another issue was the revealment of a relationship between treatment time (covering time) and quantity of NaCl penetrated in wood. To get rid of these issues, the NaCl solutions treatment must to be set up. This way can provide a uniform localization of the salt in all sample's volume, as well as a control on the wood density increment. Even the time of treatment will be reduced considerably.

With regard to modulus of elasticity (MOE) treated wood presented a value equal to 12493.32 N/mm^2, 8.83% higher than non treated wood. The comparable values of MOR and MOE for natural and NaCl treated wood are shown in Figure 1.

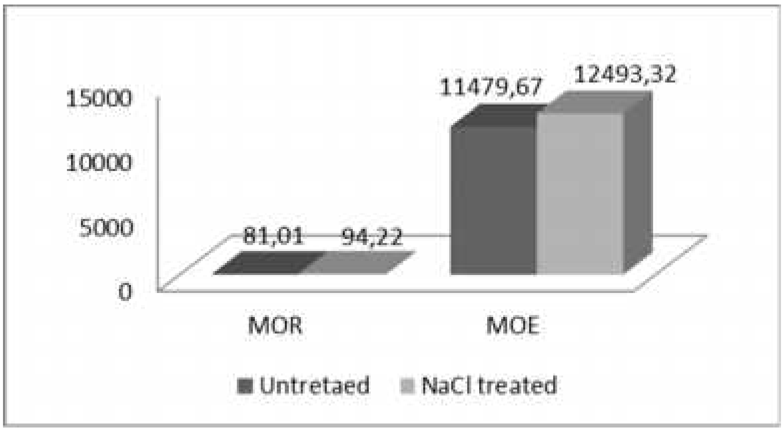

Figure 1 MOR and MOE for untreated and NaCl treated silver fir

CONCLUSIONS

Based on research results obtained during this comparison study we can say that NaCl treatment of silver fir wood presents a better performance in comparison to untreated silver fir with regard to mechanical features in static bending. The method applied full covering wood with solid NaCl for a period of 60 days, increases with 16% the bending strength of silver fir and with more than 8% its modulus of elasticity, while the weight percent gain is 9.5%. Anyway, up to now, there is no result about effects of NaCl treatment on other physical and mechanical properties of wood. Other methods of NaCl treatment have to be studied to conceive a possible application in the furure in industrial scale.

NaCl wood treatment is an ecological method which is not studied profoundly yet. It presents a simple and low cost wood modification which must be further developed with the aim to clarify shortcomings related to wood application and its performance in buildings.

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