

DETERMINING THE TENSILE STRENGTH AND OTHER PROPERTIES OF EUROPEAN BEECH (*FAGUS SYLVATICA*) WOOD IMPREGNATED WITH RAPESEED OIL

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European beech (*Fagus sylvatica*) is one of the most important Greek forest species, as it produces a great amount commercial wood valuable for exterior use. The purpose of this study was to investigate the possibility of using natural oil (rape oil) to improve beech wood properties (dimensional stability and duration). Specifically, the objective of this study was to determine the tensile strength of lap joints, water absorption and swelling of glued European beech (*Fagus sylvatica*) wood impregnated with rapeseed oil. Rape oil retention ranged between 146,51 and 294,20 kg/m³. The impregnated specimens had an absorption of about 20%, while the untreated near 60%. The rate of swelling was also decreased in impregnated specimens. The impregnated specimens had a little lower tensile strength than the untreated ones mostly when glued with polyurethane (PU).

Key words: European beech, impregnation, rape oil, swelling, tensile strength, wood modification

1. INTRODUCTION

European beech (*Fagus silvatica*) is one of ten species, from the genus of *Fagus*, found in Europe, Asia and North America. Beech wood with tall trunk, is suitable for furniture. The purpose of this article is to analyse the dimensional stability and water absorption and desorption behaviour of untreated and rapeseed oil impregnated wood. Physical and mechanical properties of beech wood harvested in the Greek public forests are well known (Skarvelis et al 2013). Octavia et al (2011) and Dubey et al (2010), investigated the dimensional stability of spruce, beech and Pine samples treated with oil. Samples were treated by immersion in bath at low temperature. The oil treated samples have showed higher dimensional stability in terms of anti-shrink efficiency and weight percent gain compared to untreated wood. Heat treatment of Scots pine (*Pinus sylvestris*) wood with rapeseed oil led to some reduction of properties such us absorption, swelling (radial and tangential), moduli of rupture and moduli of elasticity (Tjeerdsma et al 2005). Impregnation of Scots pine wood was also carried out by Epmeier et al (2005), Bak et al (2012), Kaps et al (2012a, 2012b) and Heräjärvi et al (2014). Other similar studies were made by Thevenon MF et al (2002) and Wang et al (2005).

2. MATERIALS AND METHODS

Air-dried beech wood specimens with dimensions of 5 x 5 x 10 cm were prepared for absorption and swelling tests and 33 x 13 x 1.5 cm were prepared for tensile strength. Physical defects were removed according to EN 385/2001. The material was conditioned at 20°C temperature and 65% relative humidity until the wood specimens weight was stabilized. Half of the specimens were impregnated in a steel impregnation unit using the empty cell process (Lowry method) with rape seed oil. Two types of glues were used: a poly-vinyl acetate (PVAc) glue and a polyurethane (PU) glue for exterior use were studied. The above types were applied by brush on one side of the impregnated solid wood panels. The applied end pressure was accomplished with manually operated press and lasted 60 sec. The tensile strength of glued with PVAc and PU joints specimens were examined according to EN 205/199. Tensile strength, oil retention, water absorption and swelling of the specimens were determined.

3. RESULTS AND DISCUSSION

The average air-dry density of the impregnated specimens was 0.90 g/cm^3 (std 0.02) and the average moisture content 6.88% (std 0.201). The average air-dry density of the non impregnated specimens was 0.69 g/cm^3 (std 0.02) and the average moisture content 10.38% (std 0.201). Oil retention was greater for the specimens with small dimensions compared to the specimens with large dimensions. In both cases, oil retention was sufficient (table 1).

Table 1. Oil retention from beech wood samples.

Sample dimensions (cm)	Oil retention (kg/m^3)
5 x 5 x 10	294,20
33 x 13 x 3,5	146,51

Water absorption was 1.5% for the impregnated specimens and 10% for the non impregnated specimens after eight hours. At impregnated samples the positive effect of the natural oil is apparent. We note that during the first eight hours that the samples remained submerged moisture absorption was very low (1.5%). After eight hours the absorption rate increased slightly to reach 20% in 672 hours. For non impregnated specimens, moisture absorption was beyond 20% after 48 hours. The adsorption was continued to reach approximately 54% after 672 hours. The water absorption is clearly shown in Figure 1.

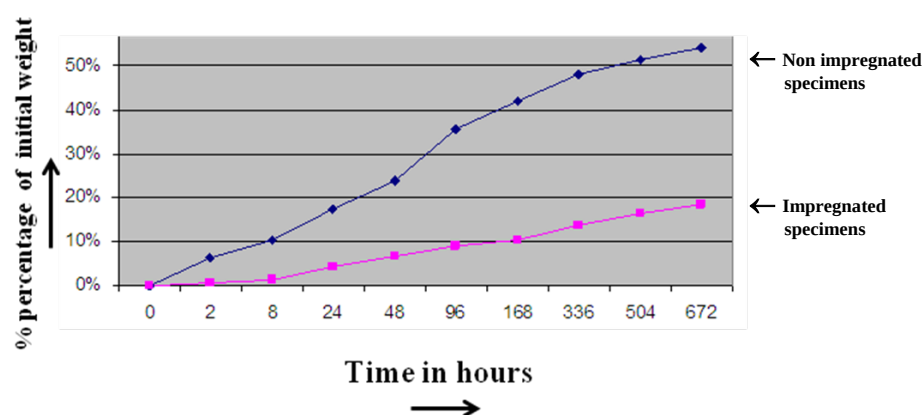


Figure 1: Water absorption for impregnated and non impregnated specimens.

The swelling data are analyzed below. We observe that the impregnated with rapeseed oil wood Beech samples remained fully immersed in water for eight hours without swelling more than 1%. The non impregnated beechwood samples showed swelling about 2% for the same period. We note that the impregnation with natural oil resulted in a slight slowdown in swelling when it comes in direct contact with water. Over the first 8 hours the non impregnated samples begin to swell faster while the impregnated samples continue to resist and swell slowly throughout the first week (168 hours).

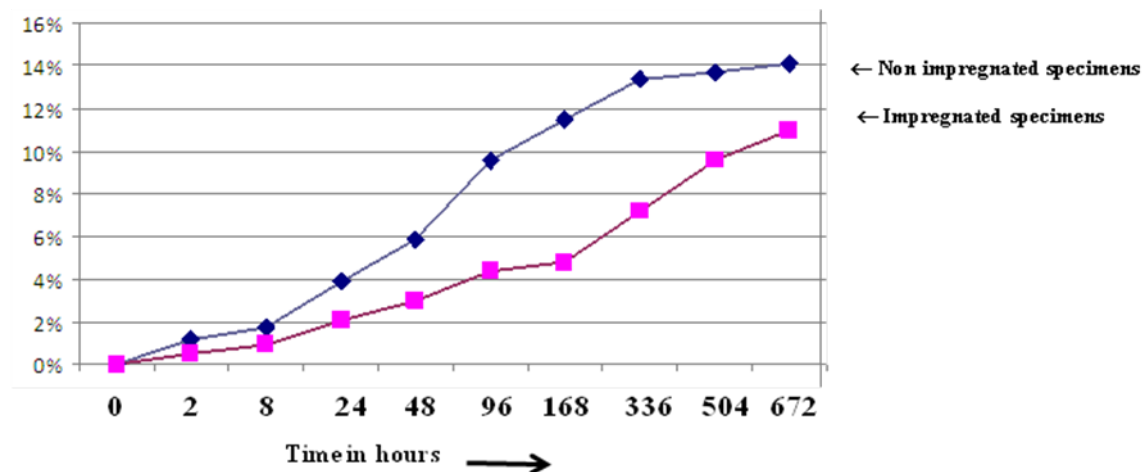


Figure 2: Beech wood swelling.

Exactly the same trends distinguished if we follow the progress of the samples swelling in tangential and radial direction separately. The non impregnated samples swell rapidly after 8 hours in the water, while the impregnated samples swell rapidly (especially in a tangential direction) after the first 168 hours (7 days) without yet reaching the same maximum swelling rates same as non-impregnated wood.

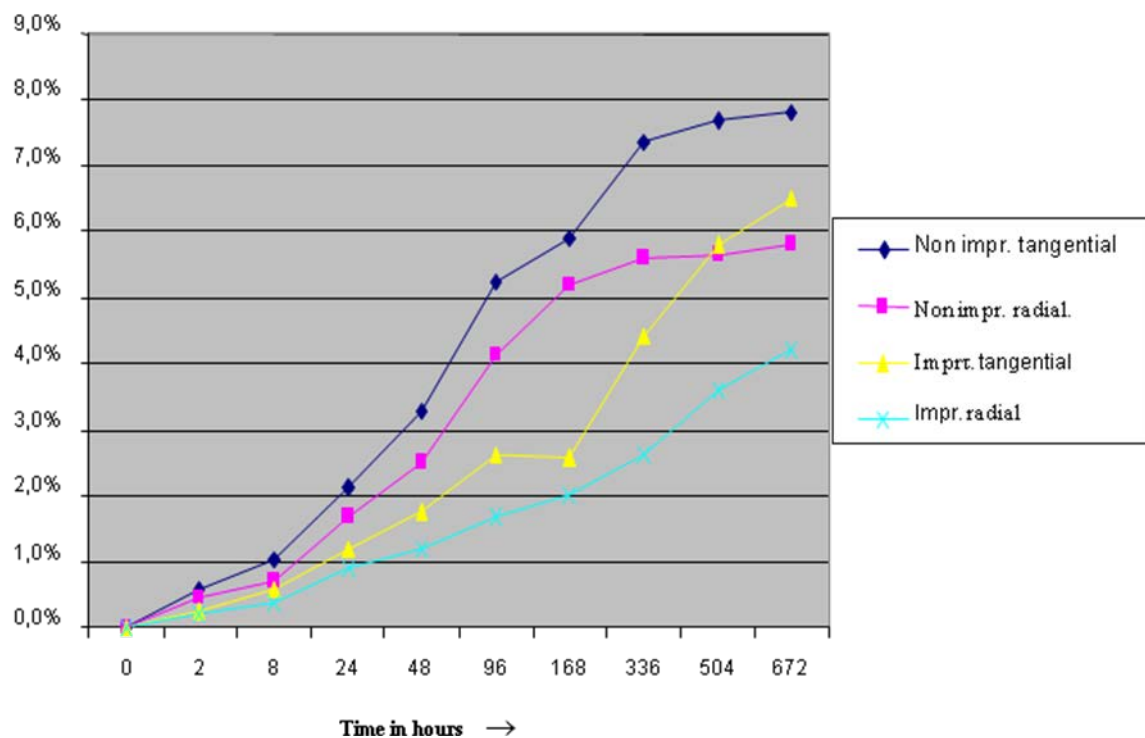


Figure 3: Swelling levels in impregnated and non-impregnated samples beech wood.

Tensile strength of the tested non impregnated and impregnated specimens fluctuated from 10.5 N/mm² down to 9.34 N/mm² when PU was used. This reflects to 10.99% reduction of tensile strength. Tensile strength of the tested non impregnated and impregnated specimens fluctuated from 10.41 N/mm² down to 9.74 N/mm² when PVAc was used. This reflects to 6.39% reduction of tensile strength.

Tensile strength of the tested impregnated specimens fluctuated from 9.34 N/mm² when PU was used to 9.74 N/mm² when PVAc was used. This reflects to 4.09% increase of tensile strength. Tensile strength of the tested non impregnated specimens fluctuated from 10.50 N/mm² when PU was used to 10.41 N/mm² when PVAc was used. This reflects to 0.87% reduction of tensile strength.

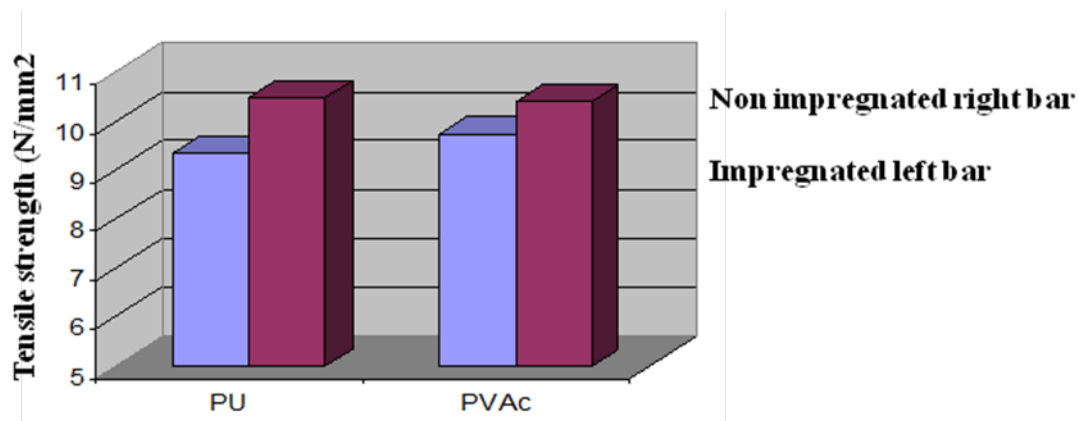


Figure 4: Tensile strength (N/mm²) beech specimens for two different types of glue (PU and PVAc).

4. CONCLUSIONS

As deduced from the experiments stability of European beech wood panels was improved. Rape oil retention ranged between 146,51 and 294,20 kg/m³ for beech wood specimens. The impregnated specimens had an absorption of about 20%, while the untreated about 60%. Swelling did not differ significantly. The impregnated specimens swelling touched eleven percent, while the non impregnated fourteen percent. Oil heat-treatment process was not found to affect the tensile strength of specimens. The impregnated specimens had a little lower tensile strength than the untreated ones mostly when glued with polyurethane (PU).

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