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SHOCK RESISTANCE OF SERBIAN SPRUCE WOOD FROM NATURAL AND PLANTED FORESTS

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Abstract: Among other things, the origin of the stand has a great influence on the quality of wood as a material. One of the important indicators of wood quality is the impact strength, because a large number of wood products crack under the influence of dynamic and not under the influence of static load. The aim of this work is to show the values of the impact bending strength (shock resistance) of Serbian spruce wood originating from natural stands and wood originating from planted forests, i.e. plantations. Correlations between impact bending strength and ring width, late wood content and wood density were determined by regression analysis.

Keywords: impact strength, Serbian spruce, natural stands, plantations.

1. INTRODUCTION

Wood is a natural material that has imperfections, which is normal, because during its creation and life it is exposed to a large number of influences, which to a lesser or greater extent affect the modification of the anatomy, shape and dimensions of the wood. One of the important factors affecting the quality of wood is its origin, i.e. whether the wood originates from natural stands or those that have been planted (plantations).

Toughness is the mechanical property that determines the wood strength when a force acts in a short time interval. Its value is determined in the bending impact test (Moreira et al., 2017). Bodig and Jayne (1993) express toughness as the energy required to cause the complete failure of a specimen. The higher the impact strength of the sample, the higher is its toughness value.

Wood elements during use can be exposed to shock loads when used in baseball bats, bridges, beams. In these cases, timber elements are more likely to fracture when subjected to impact stresses than static load stresses (Kollmann and Côté, 1968). For most purposes for which wood is used, reasonably good impact resistance is an advantage; for many uses, such as aircraft construction, sporting equipment or tool handles, it is the most important condition and therefore its measurement is an important part of routine wood testing (Pettifor, 1942).

As stated by Šoškić and Popović (2002), even the smallest deviation in the structure of the wood, the presence of defects as well as the health of the wood itself affects the impact strength, so that this property of wood varies within wide limits and the coefficient of variation of this property can be up to 32%.

2. MATERIAL AND METHOD

The research material comes from two locations of planted forests and three locations of natural Serbian spruce stands. The locality of Dubrava (DU) is near Banja Luka and the locality of Srebrenica (SR) in the vicinity of Srebrenica are locations of planted forests, and the three locations of natural Serbian spruce stands located near Višegrad are the locations of Gostilja (GO), Stolac 1 (S1) and Stolac 2 (S2).

Three 1.2 m long logs were cut from the trees. The first log was taken from a height of 1.3 to 2.5 m, the second from the part of the trunk immediately below the first green branch, and the third log was taken from a height that is in the middle between the mentioned two heights. Slats with dimensions of 20*20*1200 mm were cut from the radial boards, from which samples for testing the impact bending strength (20*20*320 mm) were made. The impact bending strength test was performed according to the regulations of the SRPS D.A1.047 standard. A total of 222 samples measuring 20*20*320 mm were tested. The test was carried out at the Faculty of Forestry of the University of Belgrade on the WT4 machine, which has a 600 mm long pendulum, at the end of which there is a 10 kg weight. Before testing, the sampes were scanned and their mass and dimensions in the radial, tangential and axial directions were determined. The impact bending strength values were obtained by testing using the form:

$$\sigma_u = \frac{W}{A} \left(\frac{J}{cm^2}\right)$$

3. RESULTS

Statistical analysis determined the values of the impact bending strength of trees from plantations (PL) and they range from a minimum of 1.94 J/cm^2 to a maximum of 5.29 J/cm^2, while its average value is 3.14 J/cm^2. The coefficient of variation is 23.56%. For trees from natural stands (NS), the average impact strength is 5.14 J/cm^2, while the minimum measured value is 2.96 J/cm^2, and the maximum is 7.77 J/cm^2. The coefficient of variation is significantly lower and amounts to 15.27%. We can see that the trees from the Srebrenica location - 3.13 J/cm^2 and the trees from the Dubrava location - 3.15 J/cm^2 have the lowest average impact strength values, that is, trees from planted forests. The trees from Stolac 2 location have the highest average value - 5.44 J/cm^2 (Table 1).

Trees from plantations have a higher coefficient of variation (Dubrava - 24.16% and Srebrenica - 23.18%) than trees from natural stands (Gostilja - 16.31%, Stolac 1 - 13.43% and Stolac 2 - 14, 84%). This can be explained by the structure of the wood as well as minor errors that existed on the samples despite efforts to minimize them.

Table 1. *Statistical analysis of shock resistance of Serbian spruce from three different stem heights*

Height of stem		Location		PL	Location			NS
		DU	SR		GO	S1	S2	
I		2,82	3,24	3,03	5,21	5,01	5,90	5,36
II		3,21	3,02	3,11	4,74	4,89	5,47	5,03
III		3,40	3,13	3,28	4,90	5,21	4,98	5,03
n		45	42	87	44	45	44	135
Ac	J/cm²	3,15	3,13	3,14	4,94	5,04	5,44	5,14
-95		2,92	2,90	2,98	4,70	4,83	5,19	5,01
+95		3,37	3,35	3,29	5,19	5,24	5,69	5,27
SD		0,76	0,73	0,74	0,81	0,68	0,81	0,78
SG		0,11	0,11	0,08	0,12	0,10	0,12	0,07
Min		1,94	2,12	1,94	2,96	3,54	4,15	2,96
Max		5,29	4,71	5,29	6,73	6,50	7,77	7,77
CV	%	24,16	23,18	23,56	16,31	13,43	14,84	15,27

Examining the impact strength of Serbian spruce, Lukić-Simonović (1970) came to the result that this strength is 3.63 J/cm^2 on average.

Analysis of the variance of the shock resistance showed that there is a statistically significant difference between the locations. Using the Duncan test, the locations were classified into three homogeneous groups (Table 2). Locations from plantations are separated into one group, while locations from natural stands are separated into two homogeneous groups.

Observing the influence of the annual ring width (arw) on the impact bending strength for all the samples that were tested (Figure 1), we can see that a negative correlation was established, which means that with the increase in the width of the growth ring, the value of the impact strength decreases. This correlation is very strong, as shown by the correlation coefficient of 0.82. The regression equation is:

$$\sigma_u = 0{,}1141 \mathrm{x} arw^2 - 1{,}3965 \mathrm{x} arw + 6{,}8655$$

Table 2. *Analysis of the variance*

	Location					ANOVA		
	DU	SR	GO	S1	S2	F	p	Post-hoc[1]
σ_u	3,15^a	3,13^a	4,95^b	5,04^b	5,44^c	95,9	0,00	3

1 The number of homogeneous groups determined by the Duncan test
a, b, c – labels of homogeneous groups

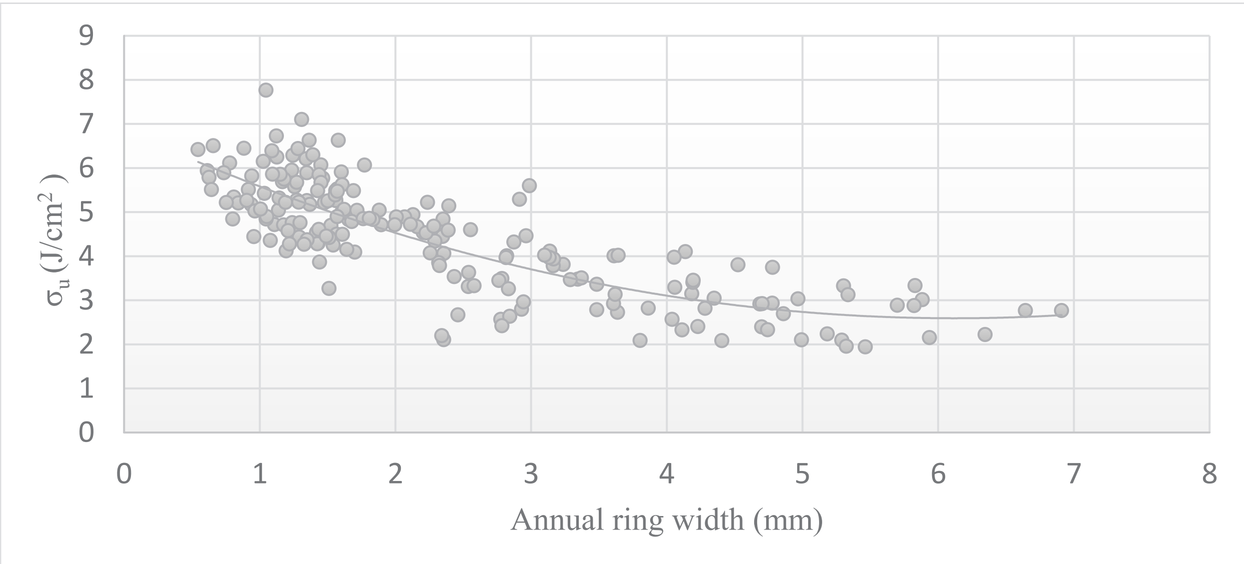

Figure 1. *Dependence of shock resistance on annual ring width*

Examining the influence of the growth ring width on the shock resistance of Serbian spruce, Lukić-Simonović (1970) came to the result that according to the correlation coefficient of 0.12, there is practically no correlation between the mentioned properties. These results differ significantly from those obtained in this study. According to Ghelmezius (1937/38), the width of growth rings does not affect this stress much, although conifers with a large width of growth rings show low values of impact stress. Higher impact stress values in samples taken from natural stands, in addition to the small width of growth rings, were primarily influenced by the fineness of the wood structure.

Figure 2 shows the dependence of the shock resistance on the proportion of late wood (plw). It can be seen that the correlation is positive, that is, with the increase in the proportion of late wood in growth rings, the impact bending strenght also increases. The correlation coefficient is 0.69, which means that the correlation is strong. The regression equation is:

$$\sigma_u = 0{,}1586 \mathrm{x} plw + 1{,}78$$

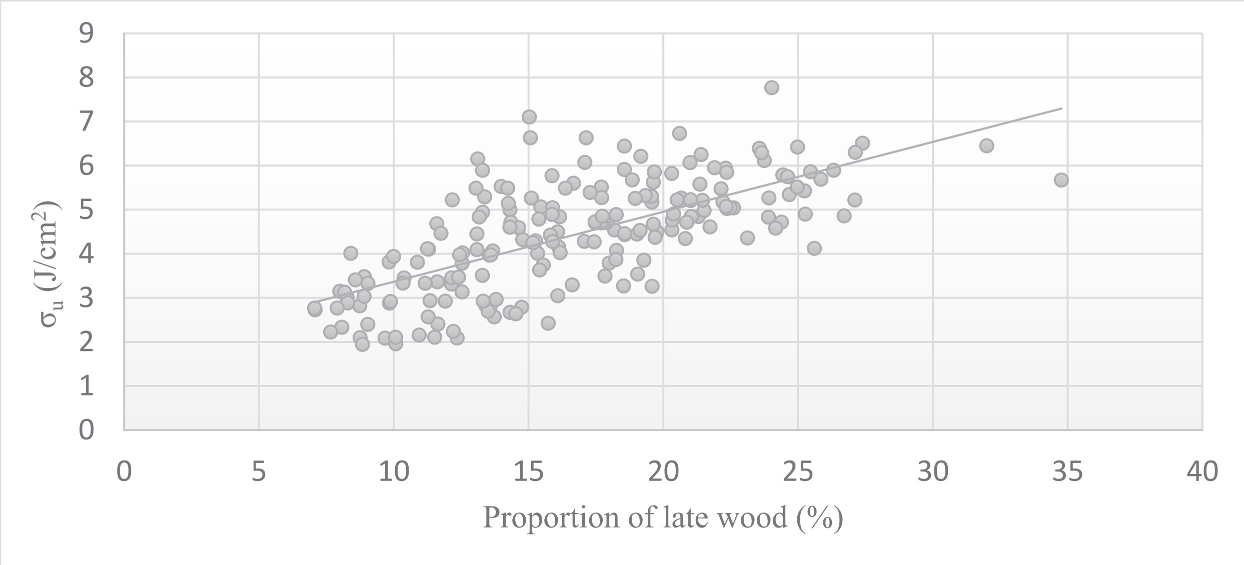

Figure 2. *Dependence of shock resistance on proportion of late wood*

As stated by Ugrenović (1950) and Šoškić and Popović (2002), it is considered that density has a positive effect on impact bending strength, but that there are differences between conifers and hardwoods, so this cannot be generalized. Lukić-Simonović (1970) came to the result that the highest impact strengths in spruce were related to the highest densities, while the lowest impact strengths were not found in test samples with the lowest density. This confirms the assumption that density by itself cannot be a reliable measure of impact bending strength.

The dependence of the impact bending strenght on the air dry density - ρ (humidity at the time of the test was 12.9% on average) for all samples is shown in Figure 3. Based on the correlation coefficient of 0.77, it can be concluded that the correlation is very strong. The regression equation is:

$$\sigma_u = 22{,}28 \text{x} \rho - 6{,}5545$$

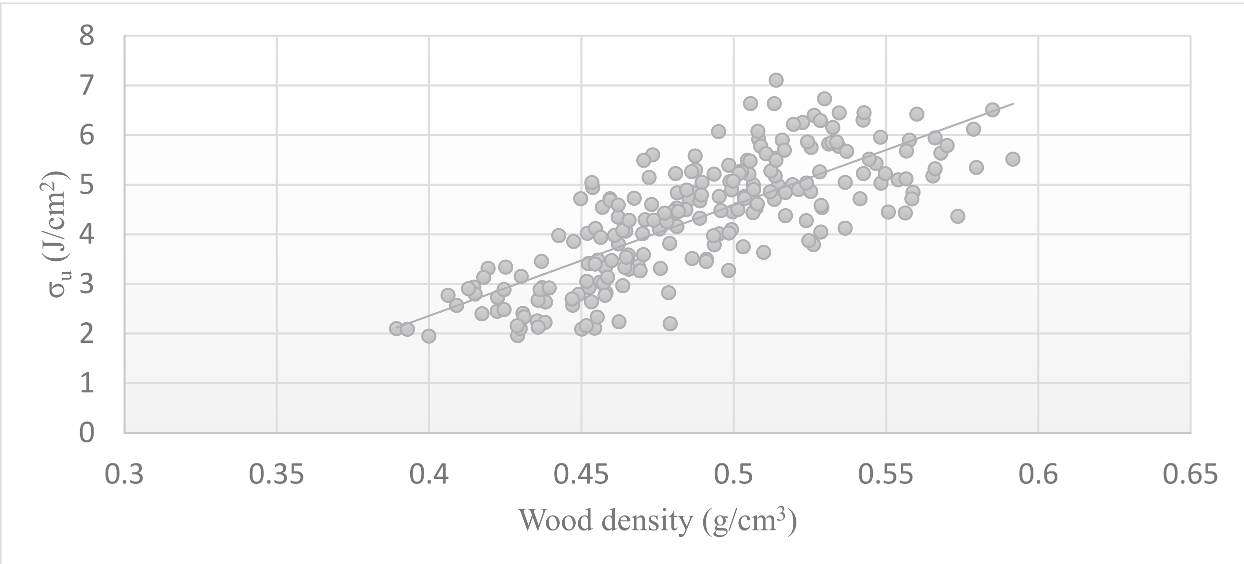

Figure 3. *Dependence of shock resistance on wood density*

4. CONCLUSION

The investigation of the shock resistance of Serbian spruce wood from natural and planted forests is significant because we got a much clearer picture of the differences in the properties of wood from stands of different origin. By analyzing the impact bending strenght of Serbian spruce wood from plantations and natural stands in the Republic of Srpska, it was obtained that the average value of the impact bending strenght for trees from plantations is 3.14 J/cm^2. The coefficient of variation is 23.56%. For trees from natural stands, the average shock resistance is 5.14 J/cm^2, while the coefficient of variation is much smaller and amounts to 15.27%.

The shock resistance shows a very strong negative dependence on the width of the growth rings for all tested samples (R=0.82). The proportion of late wood (R=0.69) and wood density (R=0.77) have a strong positive influence on this strenght.

The obtained results can help in choosing the area of application of this type of wood and can be a starting point for improving the processing of Serbian spruce wood from planted forests.

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ДИНАМИЧКА ЧВРСТОЋА НА САВИЈАЊЕ ДРВЕТА ПАНЧИЋЕВЕ ОМОРИКЕ ИЗ ПРИРОДНИХ САСТОЈИНА И КУЛТУРА

Сажетак: На квалитет дрвета као материјала између осталог велики утицај има и порекло састојине. Један од битних показатеља квалитета дрвета је динамичка чврстоћа на савијање, зато што код великог броја производа од дрвета долази до лома управо под утицајем динамичког а не под утицајем статичког оптерећења. Циљ овог рада је да прикаже које су вредности динамичке чврстоће на савијање, односно чврстоће на удар дрвета оморике које потиче из природних састојина и дрвета које потиче из вештачки подигнутих састојина односно култура. Регресионом анализом утврђене су корелације између динамичке чврстоће на савијање и ширине прстенова прираста, учешћа касног дрвета и густине дрвета.

Кључне речи: чврстоћа на удар, Панчићева оморика, природне састојине, културе.

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