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RESEARCH ON USING PLYWOOD MADE FROM DOMESTIC SPECIES OF WOOD FOR LONGBOARD MANUFACTURING

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Abstract:

The paper presents the results of the experimental research on replacing the actual plywood generally used for longboards manufacturing with plywood made from domestic species of wood, namely beech and birch wood. The research is focused on the determination of bending deformation, modulus of rupture (MOR) and modulus of elasticity (MOE) for bending strength of the investigated plywood specimens according to SR EN 310-1996, and also of the longboards made from the three types of plywood. The research was conducted on standard specimens made from beech and birch plywood on one hand, and on specimens made from a combination of bamboo and Canadian maple plywood, on the other hand, having the sizes and testing position according to SR EN 310-1996. In addition, boards having sizes and shapes of actual longboards were also tested for bending deformation, using in all cases a constant distance of 500mm between supports when applying the force, equals to the distance between track rollers of longboard. The conclusion of the research is that the domestic plywood made from beech and birch wood could replace in the future the actual plywood used in the longboard manufacturing.

Key words: *beech plywood; birch plywood; longboard; deformation.*

INTRODUCTION

Wood is used since ancient times for various applications, because of its exceptional characteristics. Among these applications, the sporting items such as tennis rackets, tennis table, ping-pong tables, basketball boards, skis, snowboards, roller boards, skate-boards and longboards require dynamic strength, elastic deformations and reliability. Skateboards and longboards are made from veneers glued together in a molding press. They are molded sandwich composites, made from veneers obtained from medium-density wood species. The final products are light, but durable and elastic, able to take over the shocks released during their use. Skateboards and longboards are used nowadays both by teenagers and adults. Commonly, the longer boards are named longboards and the shorter ones are named skateboards, as shown in Fig 1.

Fig. 1.
Skateboard vs. longboard (S vs. L 2016).

Skateboarding is the sport that uses both skateboard and longboard and it is widely used today. This sport started with “free ride” and becomes more complex and performing with “sliding” and with “sliding downhill”, “slalom” or “dancing”. What is today a truly sport and has generated an entire industry, started from the passion for surf of period of late 50`s and early 60`s who wanted to enjoy the thrill of surfing even when there were no waves on ocean. This is why the skateboard form easily can be identifying with the surfboard one. The culture of the sport has found recognition with wave and punk music, the image of punk and nervous skater has risen loud and proud (S vs. L 2016).

The new image has only served to raise the popularity of skateboarding. Skateboards are more used by children and longboard by adults and young people, because of the gears and other superior performance. Some authors (Prentiss *et al*. 2011) have made an analysis of skateboard decks, which span over all history of professional sport since 1963 in correlation with blending/hybridization process of peoples. There have been made a great number of medical studies (Rethnam *et al*. 2008) on the use of this sport as a therapeutic procedure of treating serious diseases, and related energy consumption of sportsman (Board and Browning 2014). Investigations on wood species used for skateboards, or experimental research on various types of skateboards are not present in the literature.

During their use, the longboards are subjected mainly to bending strain; therefore the modulus of rupture (MOR) and modulus of elasticity (MOE) were determined in the experimental research. Because of the impact forces required by this sport, a static force given by masses of 50-90kg becomes double or triple while riding the longboard. The strains occurred, perpendicular to the board, generate deformations, which has to be reversible in case of layered composites, because of their elastic properties. Rarely the deformations are permanent (Naidich *et al*. 1997, Kashtalian and Souts 2001). In order to investigate the longboards performance, the study of deflection and flexural strength are required. Some researchers demonstrated that in order to increase the bending strength of the laminated composite, Kevlar fibers insertions could be used in skateboards or longboards (Wang *et al*. 2016, Zrin *et al*. 2015). Low elastic properties of longboard may cause vibrations, which will be taken over by knee and column, leading to serious medical problems of the user (McKenzie *et al*. 2016). The weight of the skateboard/ longboard is also a feature that should be taken into account, because too heavy boards will be obviously more difficult to transport therefore lightweight wood species are recommended to be used as raw material.

Today, the largest manufacturer of such products is considered to be Douglas Street Manufacturing Company with a factory in the Chinese industrial city of Shenzhen. Because the wood used for manufacturing these sport articles required specific properties, the Canadian maple (*Acer saccharinum*) is preferred in producing skateboards and longboards, and sometimes it is combined with wood from bamboo species of; therefore DSM imports maple directly from Canadian region of Great Lakes, this species of wood being the most commonly used as raw material for manufacturing these types of sport articles.

OBJECTIVE

The main objective of the present research is to investigate the possibility of using plywood made of veneers obtained from domestic wood species such as beech wood (*Fagus Sylvatica)* and birch wood (*Betula Pendula*) as raw material for longboards manufacturing, considering that the board is subjected mainly to bending strains. Because of that the modulus of rupture (MOR) and modulus of elasticity (MOE) were determined in the experimental research.

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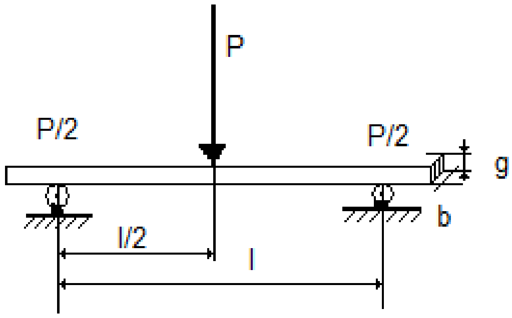
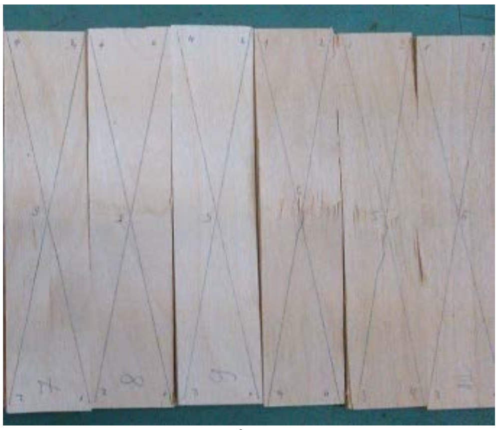
MATERIAL, METHOD, EQUIPMENT

The materials used in this study are various types of plywood with different thicknesses and different number of layers, made from one species of wood or mixed ones. Two types of specimens were tested for bending strength and deformations. First ones were cut according to SR EN 310:1996 (specimens having a width of 50mm and variable length depending on the plywood thickness) and tested for the determination of the modulus of rupture (MOR) and of the modulus of elasticity (MOE). The bending strength was determined first on standard specimens having a width of 50mm and variable length depending on the plywood thickness The second ones were specimens having the shape and dimensions of longboards with wheelbase of 500mm. Plywood boards with different thicknesses, made from beech and birch veneers were used to manufacture the specimens. Another board made from plywood obtained from mixed maple and bamboo veneers was used as to make the comparison with the new boards. The samples were cut at the sizes required by SR EN 310:1996, as follows: the length was 20 times thickness (the distance between supports), plus another 25mm from each support to the board edge. The total length could not be less than 150mm and could not exceed 1050mm. The width of each specimen was 50mm and the thickness equal with the thickness of the standard board.

If specimens failed to break even they are according to standard, the distance between supports was reduced sequentially and the new distance was specified in the test-report. The tests were performed as presented in Fig. 2a, and MOR and MOE were calculated with equations (1) and (2) respectively.



a.



b.

Fig. 2.
Bending test principle (a) and samples of 12mm thick, made from 9 layers of beech veneers, (b).

Table 1
Characteristics of the plywood samples subjected to bending strength according to SR EN 310: 1996

No.	Material	Number of layers	Dimensions (L x l) [mm]	Plywood Thickness [mm]	Distance between supports [mm]
1.	Beech plywood with longitudinal faces	7	*210 x 50*	8	160
2.	Beech plywood with longitudinal faces	7	*240 x 50*	9.5	190
3.	Beech plywood with longitudinal faces	9	*290 x 50*	12	240
4.	Birch plywood with transverse faces	9	*290 x 50*	12	240

$$MOR = \frac{3}{2} \cdot \frac{F_{max.} \cdot l}{b \cdot t^2} \quad [N/mm^2] \tag{1}$$

$$MOE = \frac{l^3 \cdot \Delta F}{4 \cdot b \cdot t^3 \cdot \Delta f} [N/mm^2] \tag{2}$$

where:

F_{max} is maximum force of rupture, expressed in N;
l – distance between supports, in mm;
b – sample width, in mm;
t – sample thickness, in mm;
ΔF – difference between the two forces in elastic field, in N;
Δf – difference between deformations for the above forces, in mm.

Besides specimens cut and tested according to SR EN 310:1996, other samples with the shape and sizes of longboard were made, including that made from maple and bamboo veneers, for making the comparison. The investigated samples had overall sizes of 800mmx250mm and were made from beech plywood in four variants, as seen in Table 2 and Fig. 4. The distance between supports was the same as that between rolls of longboard in order to compare the deformations of plywood samples (with form of longboard surface) with that of real longboard.

Table 2

Characteristics of samples type longboard subjected to deformation and bending strength

No.	Material	Number of layers	Sample dimensions (L x l x g) [mm]	Distance between supports [mm]
1.	Beech plywood with longitudinal faces, in the form of longboard	7	800 x 250 x 9.5	500
2.	Beech plywood with longitudinal faces, in the form of longboard	9	800 x 250 x 12	500
3.	Beech plywood with longitudinal faces, in the form of longboard	11	800 x 250 x 15	500
4.	Beech plywood with longitudinal faces, in the form of longboard	9	800 x 250 x 12	500
5.	Longboard from bamboo and maple	9	800 x 250 x 12.5	500

a. b.

Fig 3.
Longboard samples (a) and the determination of deformation (b).

The tests were focused on the determination of samples deformations and on the relationships between deflection and bending strength. The method used to determine the flexural deformations in case of bending tested specimens included the following sequence of operations:

- Adjustment of the distance between supports during the test, depending on the thickness of the specimens, according to SR EN 310:1996, or the distance between wheels in case of longboard samples;
- Place the specimen on the supports, so that the punch of the machine to be perpendicular to the surface of the specimen in its central part;
- Applying a constant load-increasing speed of 10 mm/min until getting a 2mm deformation;
- Note the value of the force at the deformation of 2mm;
- Repeat the procedure for bending deformations of 4mm, 6mm and so on, until the specimen's failure, when the maximum breaking force is determined in order to calculate the bending strength;
- Maximum breaking force is used in the equation (1), to calculate MOR on bending strength;
- Calculus of MOE using two consequent values of elastic deformation in equation (2).
- Processing all the results of testing and put them in diagrams.

RESULTS AND DISCUSSION

First of all, a comparison between the experimental densities of maple, birch and beech plywood was done and it was found that the densities of 608kg/m^3 for birch plywood and 799kg/m^3 for beech plywood were appropriate to those of Canadian maple plywood of 705kg/m^3. Comparing than the bending strengths it was found that the values of 56.2N/mm^2 for beech plywood with 8mm thick and 58N/mm^2 for birch plywood of 12mm thick were very close to the value of bending strength of the standard samples made of maple plywood. The same conclusion resulted for MOE, where values of 9720N/mm^2 and 9600N/mm^2 were obtained for beech plywood of 12mm thick and for birch plywood of 12mm, respectively. Fig. 4 shows that the deformation of 2…8mm for the same force of birch plywood is slightly higher than that of beech plywood, in case of specimens tested according to SR EN 310:1996, because of the differences between specimens' densities (608kg/m^3 for birch plywood and 799kg/m^3 for beech plywood).

In case of longboard samples (Fig. 5), it can be noticed that the deformation of beech plywood board is lower than in case of birch plywood longboard, as deflection values were of maximum 36mm in the first case and 44mm in the second one, and the maximum applied forces were 4000N in the first case and 3000N in the second one. In both cases, however, the variation of the deformation against forces was uniformly linear, which shows that the investigated wood species are predictable as comportment. Bal and Bektas (2014) stated also that the mechanical properties of plywood may be a good predictor for comparative studies.

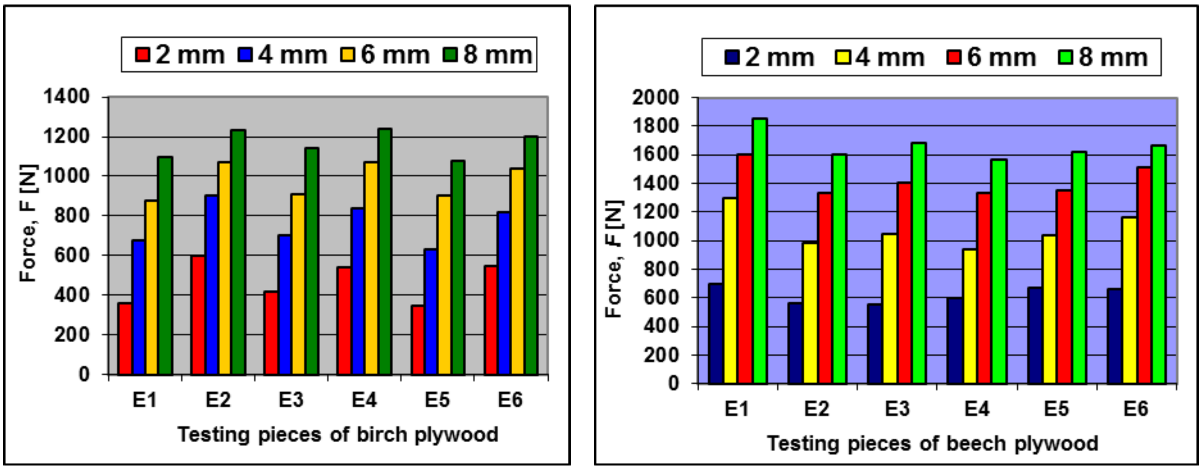


Fig. 4.
Variation of bending force against the deformation in case of samples cut according to SR EN 310:1996, from birch plywood (left) and beech plywood (right) with 9 layers of veneer and distance between supports of 240mm. E1, E2, …, E6- sample numbers.

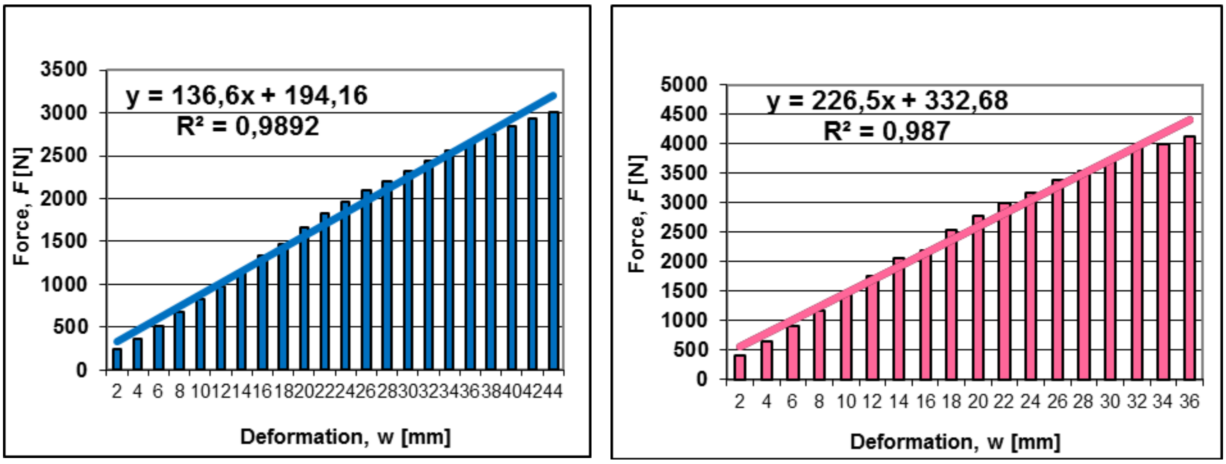


Fig. 5.
Linear variation of bending force related to deformation for longboard samples made from birch plywood (left) and beech plywood (right) with 9 layers of veneer, sizes of 800x250x12mm and distance between supports of 500mm.

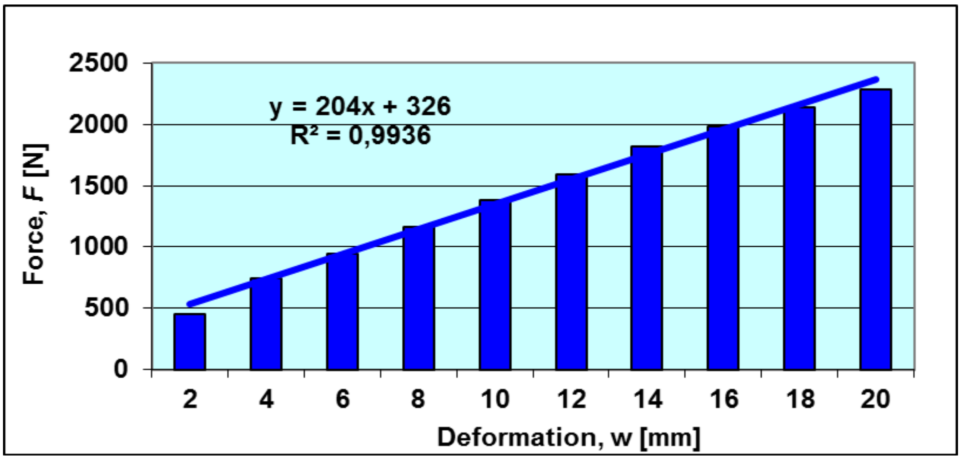


Fig. 6.
Variation of bending force related to deformation for standard longboard sample made from mixed maple-bamboo plywood with 9 layers of veneer of 800x250x12.5mm, having distance between supports of 500mm.

Fig. 6 shows that the variation of force against the deformation is also a linear one in case of standard longboard sample made from mixed maple-bamboo plywood having the faces from decorative bamboo veneer and the core from technical maple veneers. In this case the obtained values were lower than in previous cases, namely the bending strength (MOR) had the value of 46N/mm^2 and the resulted modulus of elasticity (MOE) was of 7200N/mm^2.

CONCLUSIONS

The resulted density values of the investigated materials, namely beech plywood and birch plywood were very close to that of the plywood currently used to manufacture longboards /skateboards. There are not similar experiments in the scientific literature, reason for what only comparisons between standard and longboard-form samples were made.

Comparing the values obtained for each tested material, it was noticed that the value of the bending force in case of beech veneer board with 9 layers of veneer and 12mm thick equals that applied to the board of bamboo and maple of 12.5mm thick. The highest value of bending force was obtained for the plywood made from 11 layers of beech veneer, 15mm thick. It was also noticed that the value of the bending force applied on the beech plywood made from 7 layers of veneer and of 9.5mm thick is very close to the value of the bending force applied on the birch plywood made from 9 layers of veneers and 12mm thick. So, it can be concluded that the plywood made from domestic species as beech and birch wood are, may represent a viable alternative for longboard or skateboard manufacturing. Thus, for a "cruiser" longboard, the beech plywood made from 9 layers of veneer and having a thickness of 12mm can successfully be a good alternative. Also, a longboard made from 11 layers of beech veneer and having a thickness of 15mm can provide the necessary features for “steep downhill” at high speed, which requires a higher rigidity. A longboard made from 9 layers of birch veneer and having 12mm thick, or one made from 7 layers of beech veneer and having a thickness of 9.5mm and a force of rupture over 2500N (Fig 5, Fig 6) can be a good alternative for children and adolescents, due to their light weights of40-70kg.

The general conclusion of the research presented in the paper is that the domestic species of plywood, namely beech and birch plywood can successfully replace the mixed Canadian maple – bamboo plywood, used currently in the longboard/ skateboard manufacturing.

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