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Selected construction and material aspects of moulded plywood production for use in sports equipment

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Abstract: *Selected construction and material aspects of moulded plywood production for use in sports equipment*. Within this work a study on different variants of cold glued moulded plywood intended for parts of sports equipment (eg. tops of skateboards) was carried out. 7-layer moulded plywood was diversified both in terms of the veneers arrangement (4 variants) and applied veneers (obtained from 3 types of wood: pine, beech and rock maple). Moulded plywood was made with the use of PVAc adhesive. All variants were tested for strength properties (MOR, MOE, impact bending strength and impact value). Considering the fact, that the moulded plywood used in sports equipment (eg. tops of skateboards) is most often destroyed due to dynamic forces, as the most advantageous variant of the test 7-layer plywood with two outer layers parallely glued, made of a rock maple veneers was considered.

Keywords: moulded plywood, internal structure of plywood, strength properties

INTRODUCTION

Today, moulded plywood is used in many areas of human life, including elements of sports equipment. Their use emerges from the possibility of obtaining high strength and quality parameters on the one hand and the relatively high ease of shapes moulding and processing of acquired items on the other hand. As an example of such elements can serve the tops of skateboards, which are generally manufactured with the use of traditional plywood, with veneers cross arrangement (Brooke 1999). The strength properties of plywood (including moulded plywood) depends significantly on the layout of individual layers of veneer, on their thickness and properties of the material and its pressing (Curry 1964, Curry and Hearmon 1967, Czubinskij 1992, Niemz 1993, Zhang *et al.* 1994). In traditional plywood, perpendicular fibrous texture in the contiguous veneers affects the equalization of strength properties along and across the sheet and increases its shape stability. The compensation is the more accurate the more layers there are in the plywood and the lower the thickness of a single layer is. In turn, increasing the number of layers in parallel layout improves the strength properties, measured in this direction. At the same time, it is worth noting that the specie of wood plays a distinct, although non-dominant role when it comes to strength aspects (Niemz 1993).

As mentioned before, currently produced tops of skateboards based on moulded plywood have a cross structure. However, it should be noted, that usually damage to these components is due to dynamic loads in the middle of their length. Within this study, an attempt was made to modify the veneers arrangement in plywood which was designed for top of skateboards, in order to improve its properties

MATERIAL AND METHODS

The study was divided into 2 stages. As a part of first stage of research, 4 variants of 7-layer plywood of various internal structure and a nominal thickness of 10 mm were manufactured. The structure of each variant of plywood is shown in Table 1. For the manufacture of plywood beech veneer was used, with a nominal thickness of 1.5 mm. Among examined variants of plywood, the most advantageous in terms of strength properties were selected and used in a second stage of research. As part of second stage, 7-layer plywood (with construction corresponding to the option chosen in stage I) and a nominal thickness of 10 mm, made of beech, pine and Rock maple veneers of nominal thickness of 1.5 mm were manufactured. Rock maple veneers are currently the most valued material for the skateboard's tops production.

Tab. 1 The internal structure of the different variants of plywood

Variant	Internal structure*	Description
I	│—│—│—│	typical plywood structure – perpendicular fibre direktion in the neighbouring layers
II	│—│ │ │—│	3 middle and 2 outer layers with parallel fibre direktion
III	│ │ │—│ │ │	three outer layers on both sides with the parallel fibre direktion
IV	│ │—│—│ │	2 outer layers on both sides with the middle layer of parallel fibre direktion

* │ - longitudinal fibre direktion in the veneer along the plywood sheet; — - transverse fibre direktion in the veneer along the plywood sheet.

As the binder in both stages of research, PVAc glue with the parameters shown in the table 2 was used. In the study the following parameters of pressing were applied: temperature 20°C, maximum pressure of 1.6 MPa, time of pressing 20 minutes. After manufacture, plywood was conditioned for 24 hours under laboratory conditions.

Tab. 2 Technical specification of PVAc glue

Characteristic	Value
open assembly time	10 min.
glue load	150 - 200 g/m^2
pressing time	15 – 20 min. in temp. 20 ºC, 2 – 3 min. in temp. 80 ºC
water resistance	D3 (according to PN-EN 204)
full strength time	24 h

For manufactured plywood the following parameters were tested: MOR and MOE (according to EN 310, samples dimensions: 10x50x250 mm3, fibre diretion parallel to the length of the sample in the outer layers), impact value and impact bending strength (according to PN-79/D-04104, samples dimensions: 10x20x300 mm3, fibre diretion parallel to the length of the sample in the outer layers). Ten samples were used in each test. The statistical significance of differences was determined with the use of Student's t-test for a confidence level of 95%.

RESEARCH RESULTS

Results of stage I, carried out for different arrangement of veneers in a plywood are shown in Figures 1 and 2. Considering all tested strength properties, it can be concluded that the most advantageous results were obtained for variants III and IV. Both variants are characterized by a parallel orientation of the outer layers, respectively: 3 for variant III, and 2 in case of variant IV (Table 1). Higher strength parameters of plywood variants with parallel orientation of veneers in the outer layers are connected with the fact that these layers transfer the maximum tensile and compressive strength (under the forces). In turn, wood, which is anisotropic material, has the highest tensile strength and compressive strength along the grain. It should also be mentioned that the higher variation in the plywood strength properties was observed at static destructive forces (Fig. 1). In this case, differences observed in the values of MOR and MOE for the variants I and II, III and IV are statistically significant. In case of dynamic tests (Fig. 2) differences between the variants, although appartent, are statistically insignificant. On this basis it can be assumed that the internal structure of plywood has a greater influence on carrying of static loads (long term).

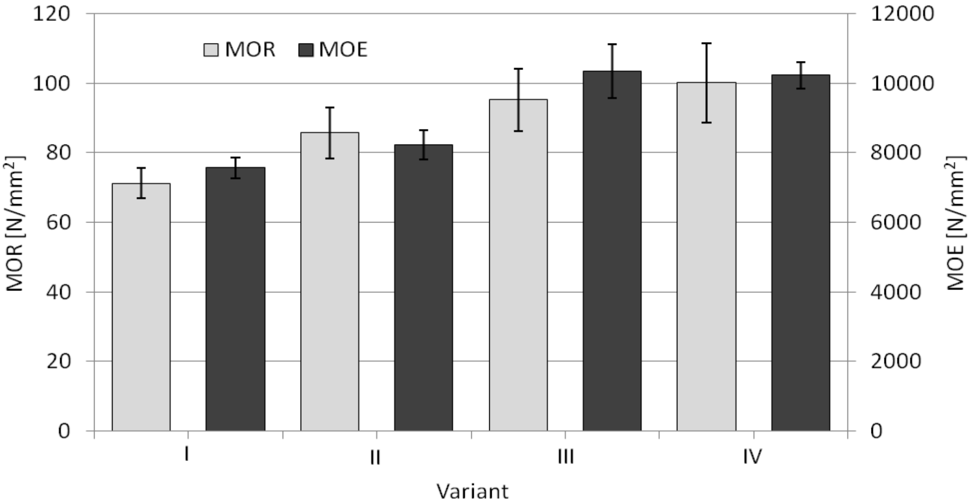

Fig. 1 Static destructive forces of moulded plywood of various internal structure.

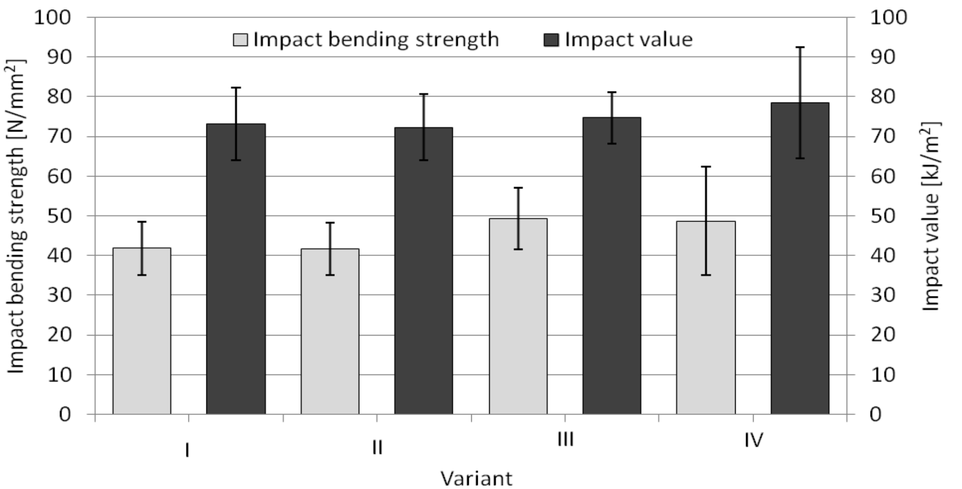

Fig. 2 Dynamic destructive forces of moulded plywood of various internal structure.

While considering variants III and IV, variant IV was chosen for stage 2. This is due to the fact that both variants were characterized by similar strength parameters, however, in the structure of variant IV there were more veneers in a transverse orientation. This suggests that this arrangement will also have a favourable strength properties in the transverse section, and better dimensional stability after manufacture and in service as well.

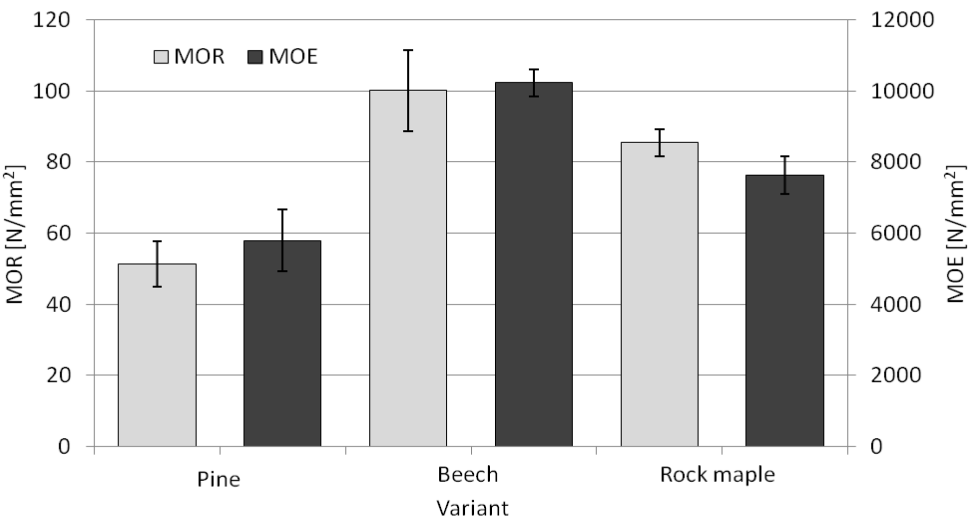

Fig. 3 Static destructive forces of moulded plywood manufactured with the use of various veneers.

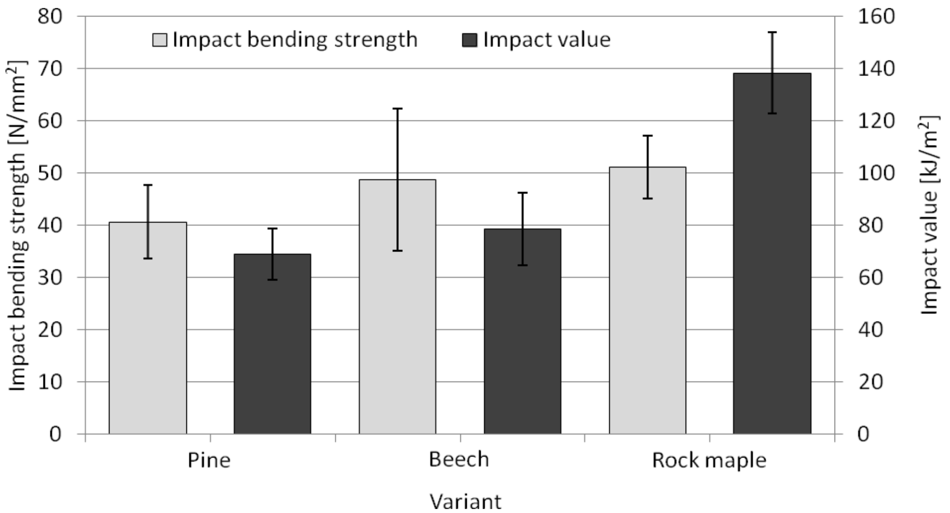

Fig. 3 Dynamic destructive forces of moulded plywood manufactured with the use of various veneers.

The results of stage 2, which were carried out on the plywood manufactured with the use of various veneers (pine, maple and beech) are shown in Figures 3 and 4. When considering the results obtained for the individual plywood, generally it can be stated that the lowest strength properties characterized plywood made from pine veneers. In almost all cases differences observed in relation to beech and maple plywood were statistically significant. The highest strength properties in case of static test (MOR and MOE) characterized beech plywood (Fig. 3). However, taking into consideration the results of the dynamic test (Fig. 4) it should be noted that maple plywood compared to beech plywood is characterized with a similar strength in case of impact bending strength and significantly improved strength in case of impact value (statistically significant difference). Taking into account that moulded plywood in sports equipment (eg. tops of skateboards) is most likely to be destroyed by the impact of dynamic forces, as the most preferred variant of the study a 7-layer plywood with two outer layers glued in parallel arrangement (variant IV) made of rock maple veneers was chosen.

CONCLUSIONS

Based on conducted study on selected variants of moulded plywood with a nominal thickness of 10 mm, for use in sports equipment (eg. tops of skateboards) the following can be concluded:

1. In 7-layer moulded plywood most preferred veneers arrangement in terms of strength involves the use of at least 2 layers in parallel orientation, and the remaining layers are assembled in perpendicular orientation.
2. The layout and number of veneer layers (4, 5 or 6 layers) in parallel orientation to the length of plywood has bigger effect on its static properties than dynamic.
3. In terms of static load (MOR and MOE) the most preferred strength parameters have moulded plywood made of beech veneers, in case of dynamic load (impact bending strength and impact value) the plywood made of rock maple veneer.
4. The most preferred variant of moulded plywood in terms of strength consists of a 7-layer plywood with two outer layers glued in parallel orientation, made of rock maple veneers.

REFERENCES

1. BROOKE M., 1999: The Concrete Wave: The History of Skateboarding. Warwick House Publishing, Toronto, Ontario.
2. CURRY W. T. 1964: The strength properties of plywood. Part 1. Compression of 3 plywoods of a standard thickness. Forest Products Research, 29.
3. CURRY W. T., HEARMON R. F. S. 1967: The strenght properties of plywood. Part 2. The effect of the geometry of construction. Forest Products Research, 33.
4. CZUBINSKIJ A. N. 1992: Formirowanije kliejewych sojedinienij driewiesiny. Izdatielstwo Sankt-Petersburskowo Uniwiersitieta, Sankt-Petersburg.
5. EN 310:1994 Wood-based panels - Determination of modulus of elasticity in bending and of bending strength
6. NIEMZ P. 1993: Physik des Holzes und der Holzwerkstoffe. DRW-Verlag
7. PN-79/D-04104-Drewno. Oznaczenie udarności i wytrzymałości na zginanie dynamiczne.
8. ZANG H. J., CHUI Y. H., SCHNEIDER M. H. 1994: Compression control and its significance in the manufacture and effects on properties of poplar LVL. Wood Science and Technology, 4.

Streszczenie: *Wybrane aspekty konstrukcyjne i materiałowe wytwarzania kształtek sklejkowych do zastosowań w sprzętach sportowych*. W ramach pracy przeprowadzono badania różnych wariantów kształtek sklejkowych klejonych na zimno przeznaczonych na elementy sprzętów sportowych (np. blaty deskorolek). 7. warstwowe kształtki sklejkowe zróżnicowane były zarówno pod względem układu fornirów (4 warianty) jak i zastosowanych fornirów (pozyskanych z 3 gatunków drewna: sosny, buka i klonu kanadyjskiego). Kształtki wykonano z wykorzystaniem kleju PVAc. Dla wytworzonych wariantów zbadano właściwości wytrzymałościowe (MOR, MOE, wytrzymałość na zginanie dynamiczne i udarność). Biorąc pod uwagę fakt, że kształtki sklejkowe w sprzętach sportowych (np. blatach deskorolkach) najczęściej ulegają zniszczeniu na skutek działania sił

dynamicznych jako najkorzystniejszy wariant z badań uznano 7-warstwową sklejkę o dwóch warstwach zewnętrznych sklejonych w układzie równoległym wykonaną z fornirów z klonu kanadyjskiego.

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