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Bending strength of layered material based on wood and foamed PVC

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Abstract: *Bending strength of layered material based on wood and foamed PVC.* The paper deals with measurement of the strength and modulus of elasticity at bending of 3–layer material according to STN EN 310. The layered material consists from two beech veneers oriented in parallel in the surface layers, and one core layer of foamed PVC. The layers are glued with PUR adhesive. Values of strength and values of modulus of elasticity at bending are compared with the corresponding parameters of commercially produced plywood boards and with lightened plywood board made from beech and poplar veneers. The values of strength and modulus of elasticity at bending along the wood fibres of surface layers of 3-layer material reached the comparable values with layered wood. In the transversal direction, the values were of lower order, what was due to parallel arrangement of veneers in the set.

Keywords: beech veneer, modulus of elasticity at bending, bending strength, layered material, foamed PVC

INTRODUCTION

Wood is a material characterised by anisotropic and relatively inhomogeneous structure consisting of the complex of macromolecular substances (cellulose, hemicellulose, lignin, and extractive substances). Wood has sufficient strength, elasticity, good thermal properties and characteristic acoustic properties (Kačík et al. 2010-Acta). Wood has many positive properties but also some weaknesses – shape instability.

Plywood was the first materials, which eliminated limitations for product size (the size was limited by size of tree trunk) and lowered the influence of wood anisotropy – by transversal crossing of veneers (Mahút et al. 1997). Transversal crossing of veneers ensured increased strength of plywood.

Tensile strength of wood across grains is orders of magnitude lower and ranges from 1.5 to 5 MPa. The strength is mainly caused by hydrogen bonds and Van der Waals power. Strength of wood in compression, for home wood species, in direction along the grain ranges from 30 to 70 MPa (Požgaj, 1997).

Strength and qualitative properties of plywood depend on the type of wood used for veneer, on veneer quality, number of veneer layers, their thickness, and veneer arrangement in plywood board (Réh, 2001).

More-layer bonding of thin wood materials (lamellas) arranged into sets by maintaining the same orientation, it is technology known as laminating (Nemec et al. 1985). Properties of layered wood are influenced mainly by wood species used, the type of glue and technology (Gáborík, 2013).

Currently, in furniture and construction industries, various light core layered materials are used. Their layers are made from veneers or non-wood materials. The example of this type of material is the light board Dendrolight – layered board containing polyurethane and possibly a layer of aluminium. Properties of this type layered wafer boards result from properties of materials used in layers and from mutual arrangement of layers and interactions between the layers.

The aim of the work was to measure values of strength and values of modulus of elasticity in bending for layered material based on beech veneer and foamed PVC; and to compare the values with commercial produced plywood and layered wood. Layers of beech veneer were bonded by polyurethane adhesive with the layer of foamed PVC.

MATERIALS AND METHODS

The 3-layer material was made from peeled beech veneer (*Fagus sylvatica* L.) and foamed PVC bonded by gluing. Specimens of 3-layer material were used for the experiments. Dimensions of the specimens were:

- beech veneer: 300 mm × 300 mm × 2.6 mm, moisture content 8 % ± 2 %, and mean density at zero moisture content $\rho_0 = 676$ kg/m^3,
- foamed PVC: 300 mm × 300 mm × 3 mm.

The material was made as: beech veneer – PVC – beech veneer. Fibre direction in both veneers was parallel. The material was glued with polyurethane adhesive Neopur 2238RRR. The adhesive is proper for gluing of sandwich panels. The adhesive was applied manually onto one side of PVC layer, coating 110 g/m^2. Files were pressed at pressing regime according to adhesive technical documentation: pressing temperature 60 °C, pressing time 10 minutes, specific pressing pressure 10 MPa.

Layered material was conditioned for 28 days in normal climate (23 ± 2 °C, 60 ± 5 %) and then the specimens of dimensions of 250 mm × 50 mm × 6.5 mm were made. One group of the specimens were made along the wood fibers and the other across the fibers.

Modulus of elasticity and bending strength were measured with measuring machine LaborTech 4.050 with 5 kN measuring head according to the STN EN 310 standard. The apparent modulus of elasticity and bending strength at breaking load were calculated.

RESULTS AND DISCUSSION

By experimental measurements we have found modulus of elasticity and bending strength for 3-layer material stressed along or across wood fibres of the surface layers. In Figure 1 we can see the comparison of modulus of elasticity for designed 3-layer material with commercially produced plywood (as stated by the manufacturer Bučina Zvolen on its website www.bucina.ddd.sk 10.06.2013) and with lightened board described by Vilhanová (2012). In the same picture, the values are compared with modulus of elasticity at bending for beech layered wood, glued with UF and PVAC adhesives, described by Gáborík and Zemiar (2002).

In Figure 2 we can see the bending strength for selected materials across wood fibres and in Figure 3 the bending strength for selected materials along wood fibres of the surface layers.

Three-layer material made from beech veneers and foamed PVC reached the value of modulus of elasticity at bending in the longitudinal direction about the same as layered wood glued with PVAC adhesive, but at the same time the value of modulus was very small in transverse direction (Fig. 1). Bending strength for tested 3-layer material in longitudinal direction was slightly higher than that for plywood material and layered wood glued with PVAC adhesive (Fig. 3). Bending strength in transverse direction was significantly lower (Fig. 2). Order of magnitude lower bending strength across the fibres of 3-layer material with foamed PVC middle layer was caused by wood ortotrophy, because veneers of the set were arranged in parallel. When comparing bending strength of chosen materials, we have to recognise that the strength of the material is influenced by the number of layers and their arrangement (Réh, 2001). In this case, we know that the layered material made from beech veneer and foamed PVC had 3 layers only, while the lightened plywood board had 7 layers. The producer Bučina a.s. Zvolen specifies only thicknesses of plywood boards (Multiplex 4 – 50 mm, beech foiled board 8 – 50 mm, combined beech and poplar board 8 – 50 mm), but not the number of layers. In both cases, the layered wood was made of 5 layers, the total thickness was of 8 mm. Plywood boards have always 3 layers minimally; and the inner layer is oriented by crossing.

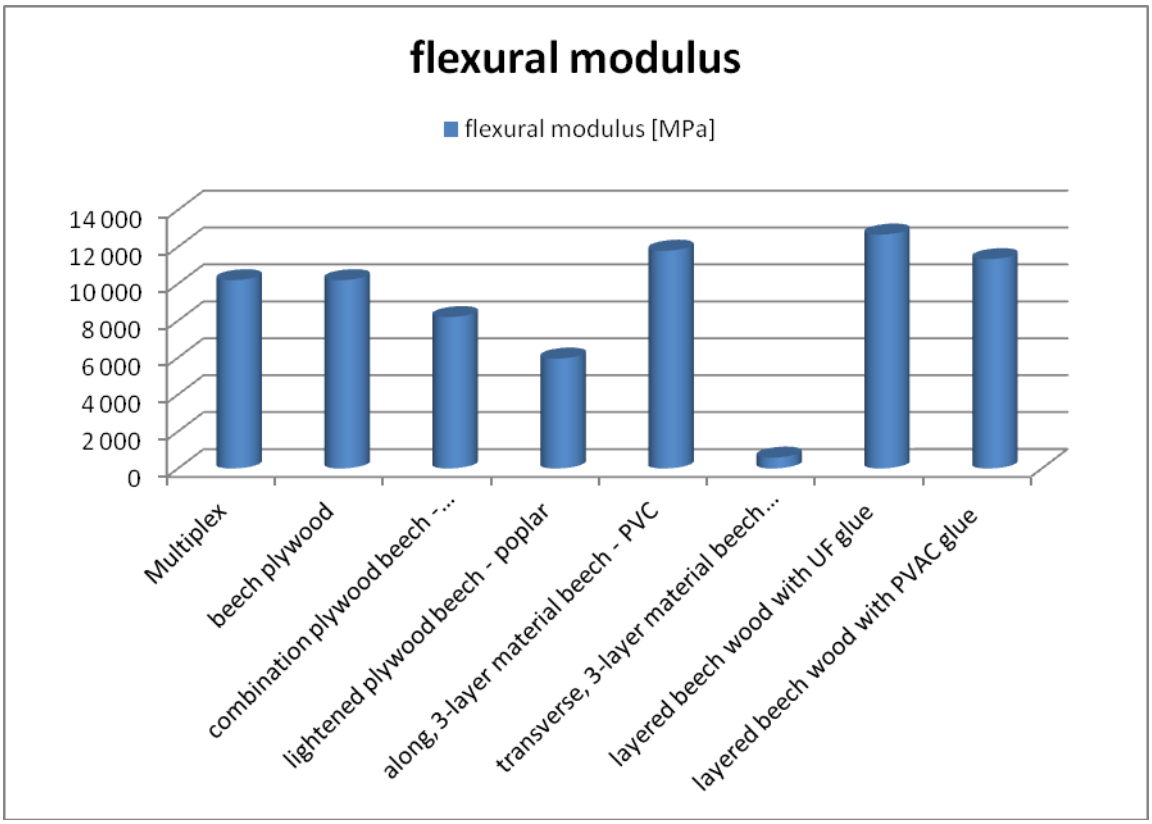

Fig. 1 Modulus of elasticity of chosen materials and layered wood

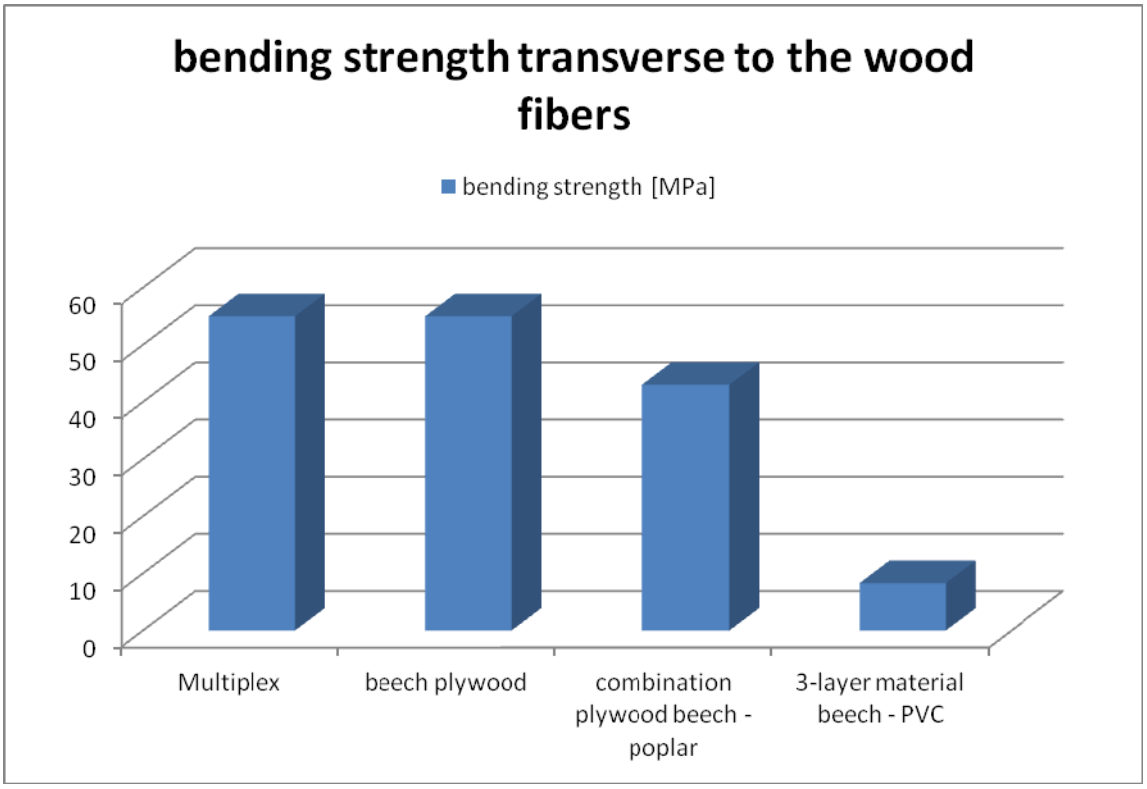

Fig. 2 Bending strength across the fibres of surface layers for chosen layered materials

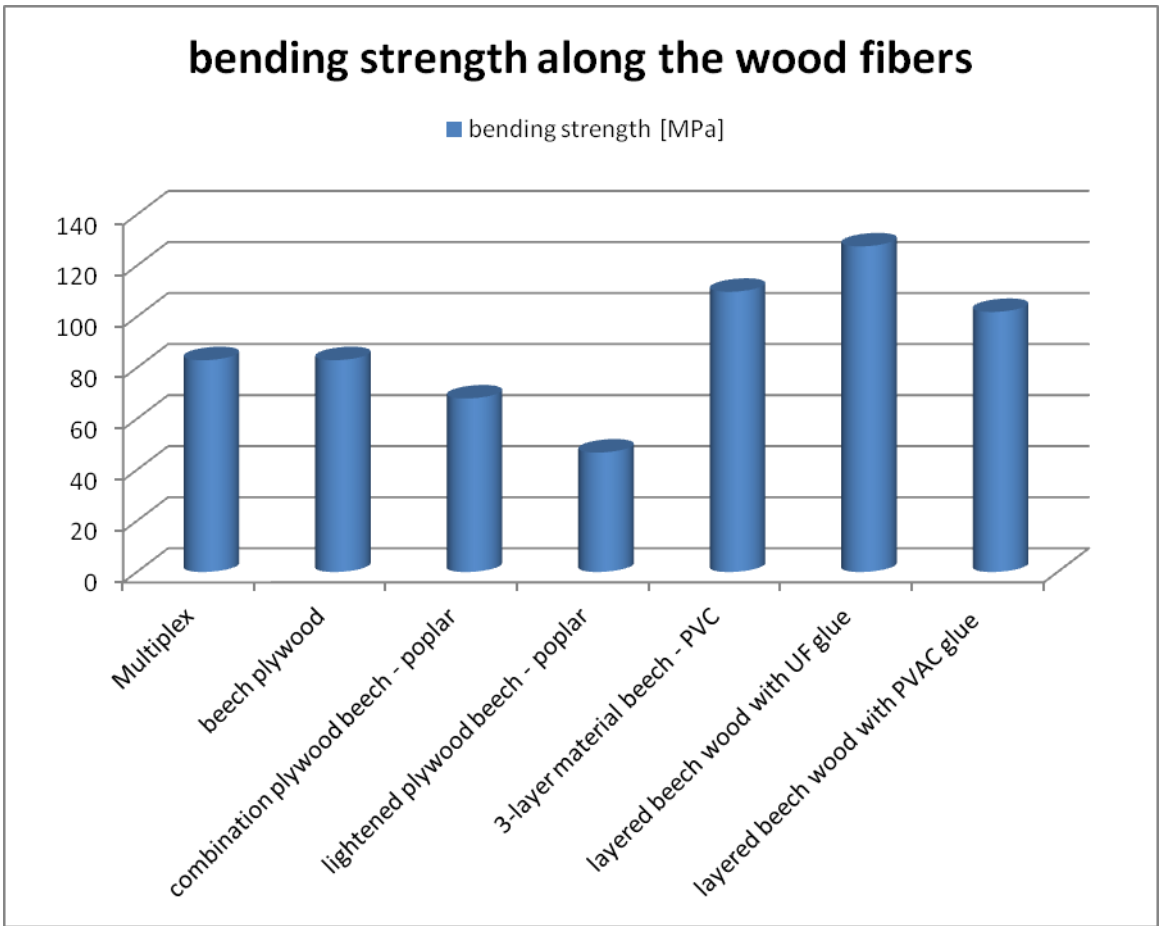

Fig. 3 Bending strength along the wood fibres of surface layers for chosen layered materials and layered wood

Ortotrophy of wood means, that wood has various mechanical and physical properties in various directions (Požgaj et al., 1997). The strength can be increased right by crossing of the individual veneer layers. The tested material had only three layers. Increasing the number of layers and crossing the layers can cause the change of strength and qualitative properties of material, as Réh (2001) describes for all-wood plywood material.

It is important to know the final application of the material in the final product. According to the product requirements we can state the parameters which have to be reached. At layered materials, the properties of the material can be influenced by suitable materials used for the individual layers, by the adhesive and the technology as Gáborík (2013) describes for layered wood. The properties of the layered material based on beech veneers and foamed PVC can compete with plywood or layered wood; it depends on orientation of veneer layers.

CONCLUSIONS

Based on measured values of strength and modulus of elasticity at bending, we can conclude:

- 3-layer material based on beech veneers and foamed PVC bonded with PUR adhesive have reached higher modulus of elasticity and also higher bending strength along the fibres than chosen plywood boards,
- 3-layer material based on beech veneers and foamed PVC bonded with PUR adhesive, when compared with beech layered wood glued with UF or PVAC adhesives, have reached very similar values of modulus of elasticity and bending strength along the fibres.

- At the same time, we have to state that modulus of elasticity and also the bending strength across the fibres have been significantly lower. The strength across the fibres can be increased by increasing the number of veneer layers and crossing them at composing the set; the strength and qualitative properties of the material have been changing.

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Streszczenie: *Wytrzymałość na zginanie materiału warstwowego wykonanego z drewna oraz spienionego PCW*. Praca dotyczy pomiarów wytrzymałości i modułu sprężystości materiału trójwarstwowego zgodnie z normą STN EN 310. Materiał składa się z dwóch równoległych warstw obłogu bukowego i warstwy wewnętrznej ze spienionego PCW, sklejonych klejem poliuretanowym. Wartości wytrzymałości i modułu porównano z bukowymi sklejkami komercyjnymi i sklejkami o obniżonej gęstości, wyprodukowanymi z buka i topoli. Wytrzymałość na zginanie i moduł sprężystości mierzone wzdłuż włókien były porównywalne z klasyczną sklejką. Wartości parametrów mierzone w poprzek włókien osiągały niższe poziomy, w związku z poprzecznym układem włókien drzewnych w materiale.

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