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THE EFFECT OF VENEERING ON THE PROPERTIES OF LIGHTWEIGHT PARTICLEBOARD WITH EXPANDED POLYSTYRENE

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ABSTRACT

Properties of non-veneered and veneered lightweight single-layer particleboard were investigated in this study. Wood particles, expanded polystyrene and UF resin were used to make boards in laboratory conditions. Rotary-cut birch veneer was used for veneering of lightweight boards. The boards were made in a thickness of 18 mm and density of 350, 450 and 550 kg/m^3 at the pressing temperature of 200 °C, pressure of 2.4 MPa and specific time of 0.23 min/mm. To make the boards, wood particles were mixed with expanded polystyrene at the weight ratio of 93:7. The UF glue consumption was 10% of the mass of absolutely dry wood particles. Modulus of rupture (MOR), modulus of elasticity (MOE), tensile strength perpendicular to the plane of board (IB), thickness swelling and water absorption of prepared particleboard were determined. It was found that veneering of lightweight particleboard by birch veneer improve their properties significantly. The results of research show that the MOR and MOE of veneered boards within density range of 350−550 kg/m^3 meet the requirements (for lightweight particleboard) of EN 16368 (types LP1 and LP2). Only the IB value of veneered boards with density of 550 kg/m^3 meets the requirements of EN 16368 (only type LP1). The MOR, MOE and IB of non-veneered boards also meet the requirements of EN 16368 (type LP1) except boards with the density of 350 kg/m^3 for MOR and MOE, and except densities of 350 and 450 kg/m^3 for IB.

Key words: lightweight particleboard, construction of the board, expanded polystyrene, veneering, physical and mechanical properties.

INTRODUCTION

Lightweight composites are becoming increasingly popular among consumers and manufacturers of furniture products (SHALBAFAN *et al.* 2013, ŠATANOVÁ *et al.* 2015). In Central Europe, every second euro spent on furniture is being used to buy lightweight furniture (THOMEN 2008). However, with a decrease in the weight of board materials, there is a significant increase in the proportion of voids and pores, and their inner structure changes, which causes the decreasing of the physical and mechanical properties of such boards. Therefore, the construction of lightweight boards requires additional research.

Today, there are many ways to achieve the light construction of boards (THOMEN 2008, DZIURKA *et al.* 2013, SHALBAFAN *et al.* 2013, BARBU 2015, DZIURKA *et al.* 2015). Particleboard with the core layer made of wood chips or rape straw, partly substituted with polystyrene (7%), were manufactured within the density range of 500–650 kg/m^3 (DZIURKA *et al.* 2015). LUEDTKE (2011) presented novel technology to produce sandwich panels with wood based facings and a foam core in one single production step. As known, the sandwich panels are generally manufactured in batch processes where the layers are firstly separately produced and later glued together. SHALBAFAN *et al.* (2013) used conventional non-bio based polymeric materials for in situ foaming. They have used expanded microspheres and expandable polystyrene beads as the core layer materials, resulting in different structures and mechanical characteristics of the foamed core layer. However, some of the challenges of the light weight wooden structure are the connection in half or final parts, resistance to water, moisture, temperature and fire, and maybe last but not least the recyclability due to the mixture of different materials like foams, plastics, etc. (BARBU 2015). The Kaurit® Light technology from BASF suggests the use of expanded polystyrene in construction of board with a top layer of MDF that makes them 20–30% lighter than traditional particleboard and the same equivalent of the strength properties (BASF 2010). Currently, the development of this technology is ongoing. Moreover, such boards are more thermo-insulating than constructional ones. For sandwich constructions of lightweight boards, Dascanova Co. uses 3D frame of corrugated cardboard or thin fibrolite (BARBU and PAULITSCH 2014).

It is known that even one-side veneering of extruded particleboard significantly (15–20 times) increases their strength and it makes possible production of hollow boards (BEKHTA 2004). Wood veneer can strengthen the construction and improve the aesthetic appearance of lightweight boards, facilitating their surface treatment.

The main aim of this study is the strengthening of lightweight particleboard with expanded polystyrene by veneering and to investigate their physical and mechanical properties.

MATERIALS AND METHODS

The industrial wood particles, rotary-cut birch veneer of the thickness 1.5 mm and moisture content of 6 ± 2%, expanded polystyrene (granules of 4-8 mm in diameter) and commercial UF resin were used for manufacturing of lightweight particleboard.

Lightweight single-layer particleboards were produced with the thickness of 18 mm and size of 300 × 300 mm, densities of 350, 450 and 550 kg/m^3. Two types of boards were made: type A – non-veneered, type B – veneered (Fig. 1). For both types, wood particles were mixed with expanded polystyrene at the weight ratio of 93:7 and the UF glue consumption was 10% of the mass of absolutely dry wood particles. UF adhesive mixture consisted of the paraffin emulsion (15.7 mass parts to 100 mass parts of their resin solution) and hardener ammonium nitrate, in the form of an aqueous solution at a concentration of 20% (5 mass parts to 100 mass parts of their resin solution) were added to UF resin.

Boards were prepared by the mixing of wood particles with expanded polystyrene and UF adhesive in the laboratory drum blender. Firstly, wood particles and one half of the glue were loaded into the blender and mixed for 10 minutes. After that, expanded polystyrene and the rest of the glue were added and then this mixture was continually blended during the additional 5 minutes to obtain the homogeneous composition. In the case of boards without expanded polystyrene (type A), the completely wood particles and whole batch of glue were loaded into the laboratory drum blender, and mixed for 15 minutes. For board type A, the formed mat was placed directly on a metal plate. For board type B, the formed mat was placed between the veneers with the spread of UF adhesive in amount of 150 g/m^2 and then placed on the metal plate. The formed mats of both types were pre-compressed in a cold press for 10 minutes before hot pressing.

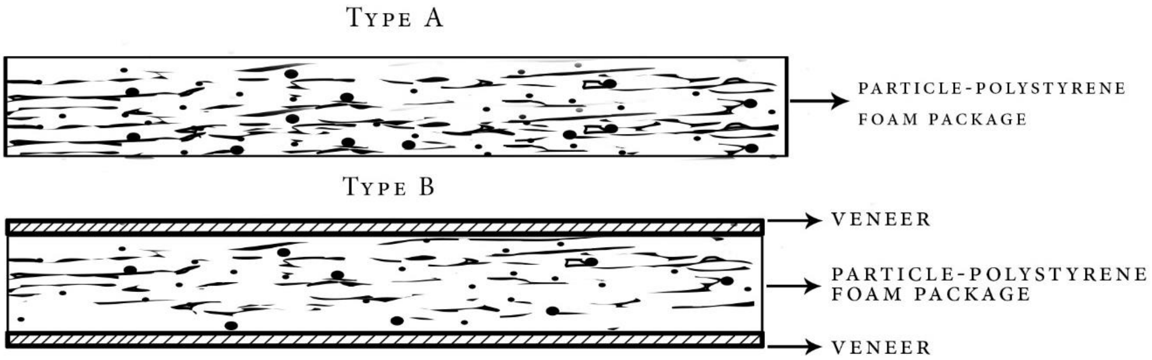

Fig. 1 Types of lightweight particleboard.

The pressing process was carried out in a hot press using distant gaskets. The boards were pressed at the temperature of 200 °C, pressure of 2.4 MPa and pressing time of 14 s/mm in the one-step process. The obtained boards were conditioned for seven days and then cut into samples to determine their physical and mechanical properties (modulus of rupture (MOR) and modulus of elasticity (MOE), tensile strength perpendicular to the plane of board – internal bond (IB), thickness swelling and water absorption) according to standards EN 310, EN 319 and EN 317.

RESULTS AND DISCUSSION

As the results of the study, it was found, that the MOR and MOE in board type B are higher than in board type A (Fig. 2 and 3). It can be clearly seen that the veneering improved MOR and MOE significantly. Moreover, the values of MOR and MOE increased with rising density of both types of lightweight particleboard. The increasing values of MOR were 259%, 366% and 416%, and MOE were 460%, 437% and 425% for boards type B with density 350, 450 and 550 kg/m^3, respectively. The similar trend in increasing MOR and MOE can be observed for the boards type A. It is generally known that with increasing density of boards MOR increases practically proportionally. SCHIRP *et al.* (2008) were also found that the MOR and MOE are proportional to the density of boards.

The results of this study have shown that values of MOR and MOE of lightweight particleboard type A and B within the density range of 350–550 kg/m^3 meet the requirements for lightweight particleboard according to EN 16368.

The influence of the type and density of boards on their IB is presented on Fig. 4. It was established that the IB of the lightweight board does not depend on the studied construction of the boards and rises proportionally with increasing density. This fact agrees well with the well-known assertions that density affects and determines the strength of the composite boards (MALONEY 1993). However, it should be stated that IB of lightweight boards type A with density 450 and 550 kg/m^3 and type B only with density 550 kg/m^3 meets the requirements of EN 16368 (only type LP1). The IB values of boards with density 350 kg/m^3 (type A and B) and 450 kg/m^3 (type A) does not meet these requirements. This can be explained by the fact that the volume of expanded polystyrene in boards with density 350 or 450 kg/m^3 is larger than in boards with density 550 kg/m^3. SHALBAFAN *et al.* (2016) also found in their study that the minimum requirement of IB values according to EN 312/P2 (0.35 N/mm^2) is fulfilled by the panels with the density of 550 kg/m^3.

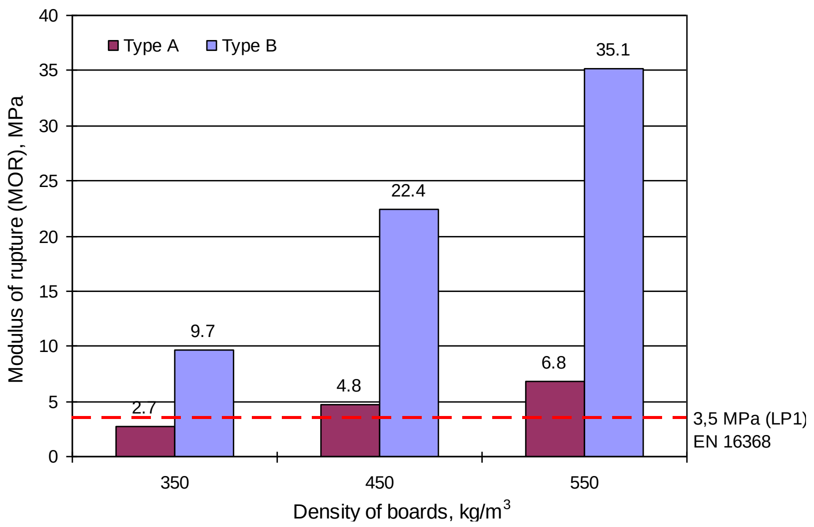

Fig. 2 Modulus of rupture of lightweight particleboard.

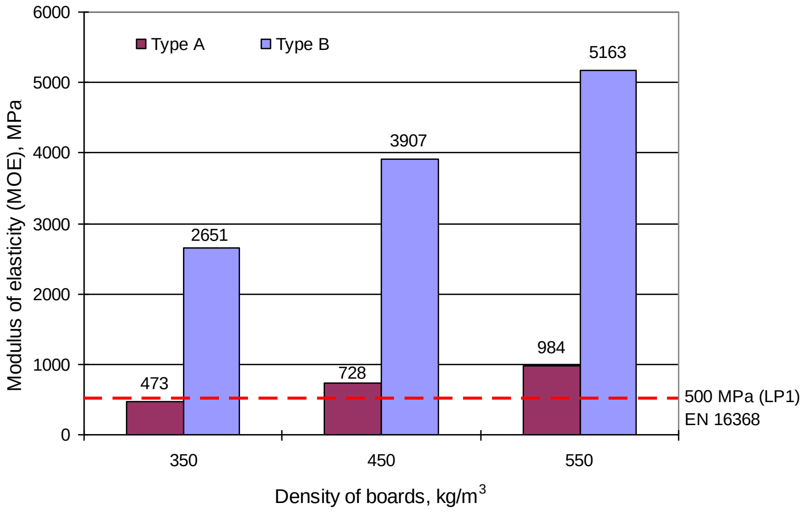

Fig. 3 Modulus of elasticity of lightweight particleboard.

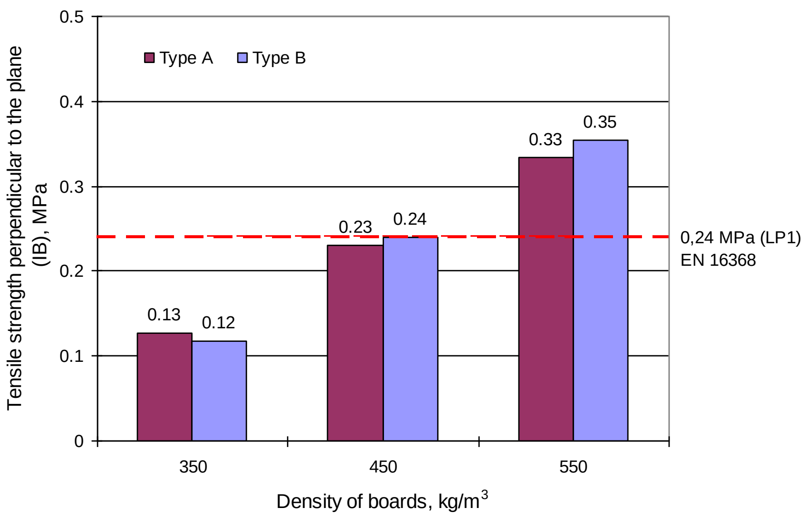

Fig. 4 Tensile strength perpendicular to the plane of lightweight particleboard.

Expanded polystyrene is the least durable material among components of lightweight boards, so the destruction of the board samples during IB test occurs precisely in the places of polystyrene concentration. There was no delamination of the veneer observed from the particle-polystyrene package in the samples during IB tests.

Thickness swelling values after 2 respectively 24 hours immersion in water is shown in Fig. 5. It was established that the boards type B are swollen less than boards type A. The thickness swelling after 2 hours for boards type A was 60%, 62% and 67% higher than for boards type B with the density 350, 450 and 550 kg/m^3, respectively. This is due to the protective surface effect of the veneer in the board type B, which prevents water from penetrating into its porous structure.

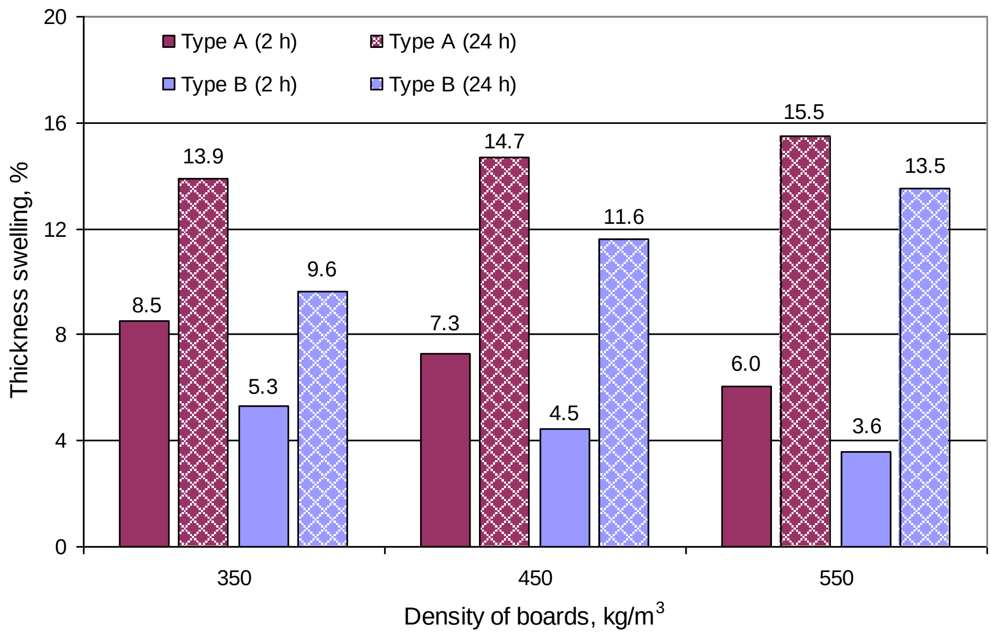

Fig. 5 Thickness swelling of lightweight particleboard.

Thickness swelling after 24 hours of the boards type A was higher than those of type B on 45%, 27%, and 15% for densities of 350, 450 and 550 kg/m^3, respectively. Moreover, thickness swelling increases with the increasing density of boards. The panels with lower density (450 kg/m^3) have slightly higher TS values due to more voids existing in the lighter panels (SHALBAFAN *et al.* 2016). DZIURKA *et al.* (2013) were also found that elevated gluing degree of the core layer supplemented with rape straw and expanded polystyrene was accompanied by reduced water absorption and swelling after 24 hours of immersion in the water. Improved hydrophobic properties were a function of the adhesive type and expanded polystyrene.

The water absorption values of investigated boards during 2 and 24 hours are shown in Fig. 6. The water absorption after 2 hours was decreased for both types (A and B) of boards on 24%, 20% and 8% for densities 350, 450 and 550 kg/m^3 respectively. The content of the pores is smaller in the boards with high density, so the absorption of water is less. The difference in the water absorption values after 24 hours between boards type A and B was increasing on 15% 18% and 23% for the density 350, 450 and 550 kg/m^3, respectively.

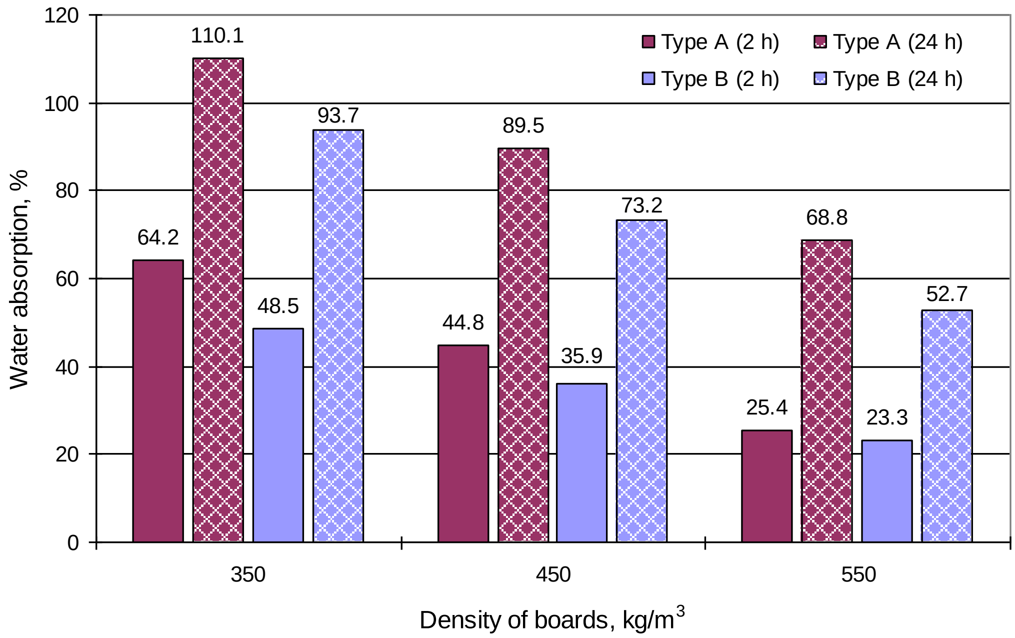

Fig. 6 Water absorption of lightweight particleboard.

Water absorption after 24 hours was decreased with increasing the board's density in the studied range. Moreover, this decrease was higher in the boards' type B. These results may be explained by the presence of hydrophobic expanded polystyrene in the boards and veneering the board type B.

CONCLUSIONS

Physical and mechanical properties of veneered and non-veneered lightweight particleboard containing expanded polystyrene were investigated in this study. The veneering of lightweight particleboard by birch veneer significantly improved their physical and mechanical properties. The results of the study have shown that the MOR and MOE of veneered lightweight particleboard within the density range of 350–450–550 kg/m^3 meet the requirements for lightweight particleboard according to EN 16368 (types LP1 and LP2). The IB values of veneered lightweight boards with density of 450 and 550 kg/m^3 and non-veneered boards only with density of 550 kg/m^3 meet the requirements of EN 16368 (only type LP1). Veneered lightweight particleboard have less thickness swelling and water absorption than non-veneered boards.

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