ONLINE ISSN 2069-7430
ISSN-L 1841-4737

PRO LIGNO
www.proligno.ro

Vol. 10 N° 1 2014
pp. 31-37

RESEARCH ON THE OPTIMUM EMBEDMENT DEPTH OF THE DOWEL PINS INTO THE PARTICLEBOARD JOINTS

Adriana FOTIN
Lecturer dr.eng. – TRANSILVANIA University in Brasov – Faculty of Wood Engineering
Address: B-dul Eroilor nr. 29, 50036 Brasov, Romania
E-mail: adrianafotin@unitbv.ro

Luminiţa-Maria BRENCI
Assist.prof.dr.eng. – TRANSILVANIA University in Brasov – Faculty of Wood Engineering
Address: B-dul Eroilor nr. 29, 50036 Brasov, Romania
E-mail: brenlu@unitbv.ro

Abstract:

In this paper the authors intend to present the results of the experimental research on the dowel joints applied for 18mm particleboard panels, in order to determine the optimal embedment depth of the dowels, depending on the mechanical resistance of the joint. For this purpose edge to edge joints and "T" type joints of the particleboard panels have been made, using dowel pins of different diameters (6, 8 and 10mm) and various embedment depths (10, 15, 18, 20 and 25mm). These joints were subjected to parallel and respectively perpendicular tensile stresses, depending on the joint type. The experimental results show that the tensile strength, no matter if parallel or perpendicular, increases with the increasing of the embedment depth of the dowel, the best values being recorded for the applied dowels of 8mm diameter.

Key words: *dowel; tensile strength; optimal; embedment depth.*

INTRODUCTION

The highest percentage of the wood joints is represented by the glued joints (fixed ones).

The quality of the glued joint is widely appreciated by its resistance to various mechanical, physical and chemical factors and it is achieved by the adhesion between the adhesive film and the surface of the glued element. The type of the adhesion forces and their sizes depend on the chemical composition of the adhesive and the type of the support element.

The wood glued joints will have different characteristics depending on the interaction, or the adhesive compatibility with the support elements (Curtu 1988).

If high resistance is required for a joint, then those with large gluing surfaces are preferred. The glued joint surface is critical for the loads that it can bear (Curtu 1984).

One of the most widespread methods of fixed jointing in case of wood-based panels (particleboard, MDF) is dowel pins jointing. Some researchers (Tankut 2009) have studied the rigidity of furniture cases using unglued and glued joints with screws on one hand and wood dowels on the other hand, noting that the presence of the adhesive increases this property by 42% for screw joints and by 33% for dowel joints.

The strength of "T" type joint, but for the solid wood, has been theoretically studied using ANOVA (Najafi 2013) for the case of wood dowels of 10mm diameter joints, subjected to shear and withdrawal tests, in the condition of machining the diameter of the embedment hole equal to and 0.5mm smaller than the diameter of the dowel. Recommendations on the dimensions of dowel diameter and the embedment hole diameter have been done as the result of the above mentioned study. The finite element method was applied to “L-type” solid wood corner joint (Smardzewski *et al.* 2011) when using dowels of 8mm diameter and when the joint was subjected to opening and closing tests, achieving thus the distribution of strains and deflections and also the mathematical models for determining the joint linear elasticity modulus.

The experimental research on the edge to edge joint of wood-based panels (particleboard and MDF) using dowels of 6, 8 and 10mm diameters was performed by some researchers (Kurt *et al*. 2009) when withdrawal tests were carried out. The embedment holes were machined to 20mm depth, several types of adhesive were used and several types of solid wood edge banding of the composites, and the results showed that the more resistant variant of joint is for MDF panels, using dowels of 8mm diameter and a solid wood edge banding of 5mm thick. For the L-type corner joint of the particleboard panels, the influence of the dowel diameter and of the embedment depth have been investigated (Zhang *et al*. 1993) by bending strength tests, resulting thus an optimum depth of dowel embedment of 1 inch.

Other studies (Norvydas *et al.* 2005) have shown that for the L-type corner dowel joint of the particleboard the strength of joints increases by 12–22% when dowel diameter changes from 8 to 10mm and increases by 48–63% when thick of particleboard changes from 16 to 18mm.

The authors of the paper intend to continue the research in the field and to determine the optimal dowel embedment depth for edge to edge and T-type joints for various dowel diameters (6, 8 and 10mm).

OBJECTIVES

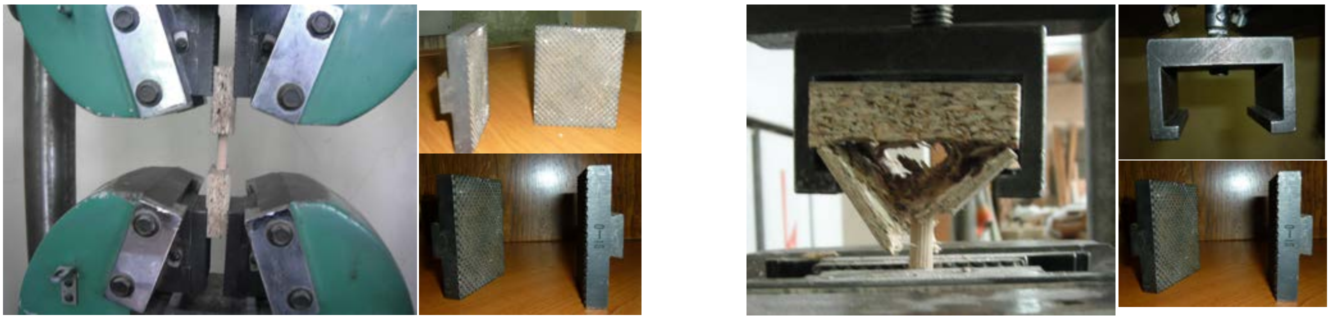
The main objective of the present study is to determine the optimal dowel embedment depth, depending on the perpendicular and parallel tensile strengths of the joint of 18mm thick particleboard panels, for different diameters of the dowels (6, 8 and 10mm), in the conditions the panels are edge to edge or "T-type" shape joined.

METHOD, MATERIALS AND EQUIPMENT

In order to determine the tensile strengths of the dowel joints of particleboard, the following materials were used: Kronospan melamine faced particleboard of 18mm thickness and a density of 700Kg/m^3 for the jointed specimens, beech wood dowels with sizes of Φ6x50mm, Φ8x60mm and Φ10x70mm for the joints; Kleiberit D 303/D3 (D3 resistance class) as adhesive (Fig. 1).

Fig. 1
Materials used for the dowel joints.

In the first stage, the 18mm thick particleboard was cut into specimens of 50x50mm sizes, according to the dimensions of the mounting devices of the universal testing machine (Fig. 2.a and b), specific to the parallel testing (Fig. 2.a) and perpendicular (Fig. 2.b) respectively one.



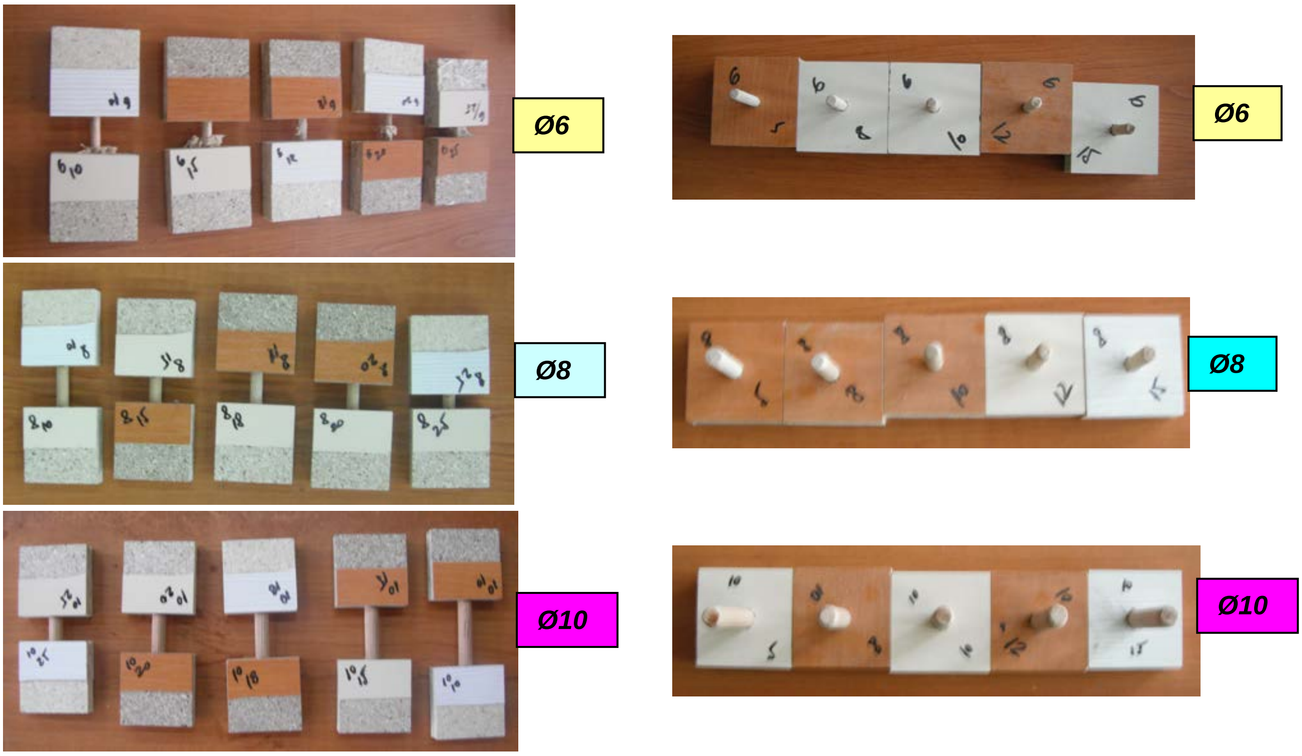
a b

Fig. 2
The specimens testing on the universal testing machine and the required devices; a – for parallel tensile test; b – for perpendicular tensile test.

For the determination of the parallel tensile strength, the specimens were dowel edge to edge jointed by beech wood dowels of 6, 8 and 10mm diameters, the same embedment depth being machined on the edge, respectively 10, 15, 18, 20 and 25mm. The bonding adhesive D30 Kleiberit was applied manually in the embedment hole (Fig. 3.a).

On the other hand, for the determination of the perpendicular tensile strength, the holes of 6, 8 and 10mm diameter (Φ) were drilled on the surface of the specimens, the embedment depth of the holes being succesively of 5, 8, 10, 12 and 15mm (Fig. 3.b).

ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 10 N° 1 2014
pp. 31-37



a **b**

Fig. 3
The specimens used for the tests; a – for parallel tensile test; b – for perpendicular tensile test.

The tensile test applied on the specimens was performed at a speed of 4,5mm/min.

After completion of assembly of the specimens by glued beech wood dowels, they were conditioned for 24 hours at a temperature of 20^0C ± 2^0C and a relative humidity of the air of 55-60%. The parallel or perpendicular tensile tests were carried out to the joint after 24 hours, when first the specimens were milled in a width of 25mm and a thickness of 2mm on each side, in order to achieve a proper fastening in the testing equipment device and to avoid the device slipping on the melamine faced particleboard.

A total amount of 45 test specimens were cut, 30 of them were tested to parallel tensile strains and the other 15 were tested for the perpendicular tensile strains, five sets to each diameter of dowel. The specimens were subjected to tensile strength until breaking (withdrawal).

The glued surface of the dowels was calculated using the Equation (1):

$$S_i = \pi \cdot \phi \cdot Li = \pi \cdot \phi \cdot (Lt - 1) \text{, in mm}^2 \qquad (1)$$

Where: Φ- is the diameter of the dowel in mm,
Li – is the glued length of the dowel.

Due to the fact that the dowel has a chamfer of 1mm, when calculating the glued surface, 1mm of the glued length, Li, is substracted.

The parallel (perpendicular) tensile strength was calculated using Equation (2):

$$\sigma_{t_{//(\perp)}} = \frac{F}{S_i} \text{, in daN/cm}^2 \qquad (2)$$

Where: F is the withdrawal force and
S_i – glued surface.

RESULTS AND DISCUSSIONS

The results of the withdrawal forces of the dowels of 6, 8 and 10mm diameters jointed succesively at embedment depths of 10, 15, 18, 20 and 25mm as edge to edge joint type of 18mm thick particleboard, when parallel tensile strains were applied, are presented in the diagram of Fig. 4.

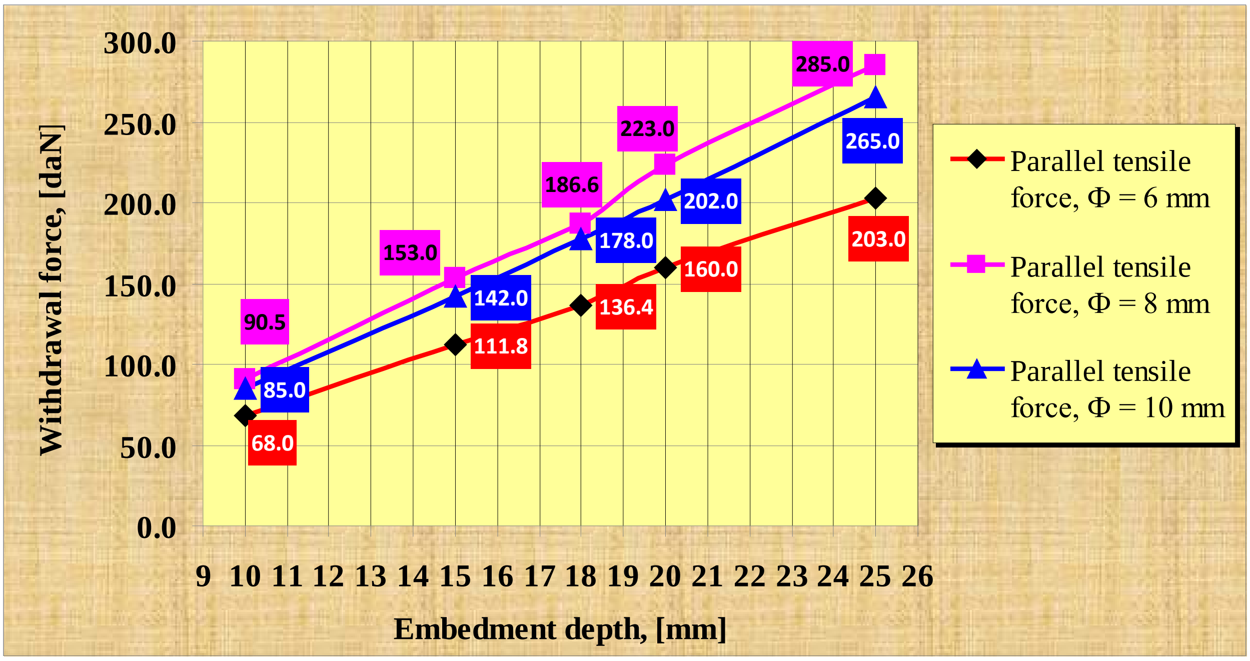


Fig. 4

Withdrawal force for parallel tensile test in case of edge to edge joint of 18mm thick particleboard panels, for various embedment depths of the dowels with diameters of 6, 8, 10mm.

The results of the withdrawal forces of the dowels with diameters of 6, 8 and 10mm jointing the 18mm thick particleboard to succesively embedment depths of 5, 8, 10, 12 and 15mm within "L" or "T"- shape joint types, which were subjected to perpendicular tensile stresses, are shown in the diagram in Fig. 5.

The comparison of the results for the two types of strains applied on the 18mm thick particleboard dowel joints with diameters of 6, 8 and 10mm is shown in the diagram in Fig. 6, where the values of the withdrawal forces are compared.

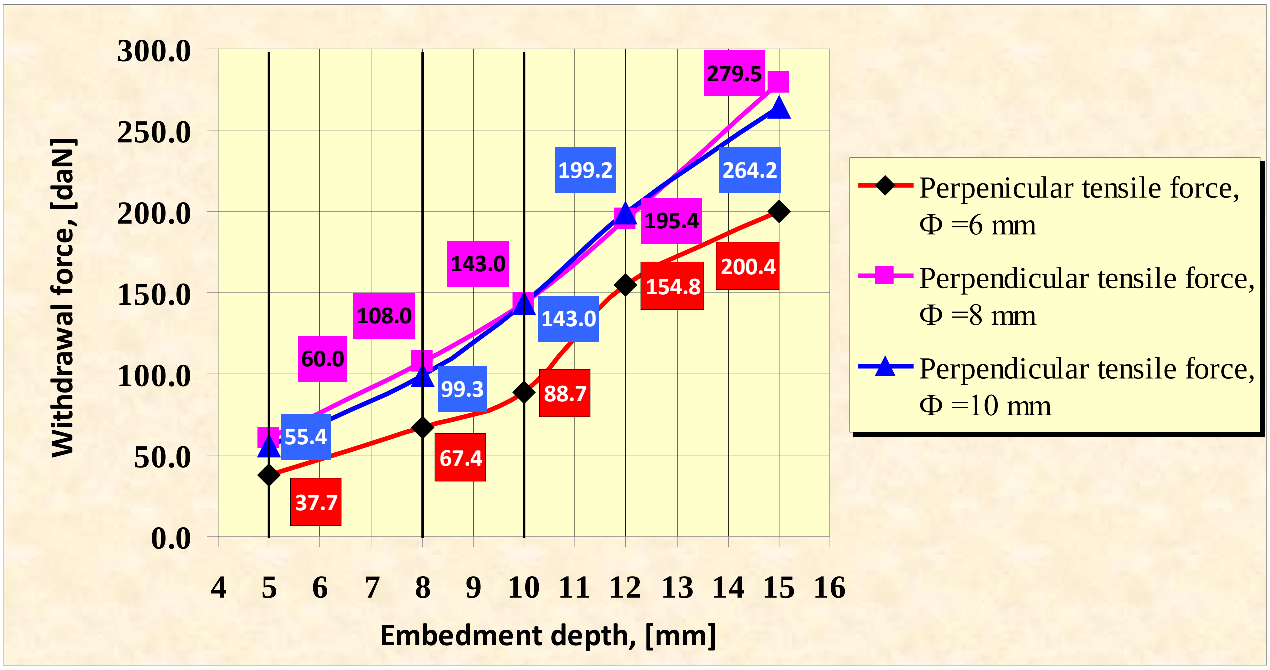


Fig. 5

Withdrawal force for perpendicular tensile test in case of „T-shape" type joint of 18mm thick particleboard panels, for various embedment depths of the dowels with diameters of 6, 8, 10mm.

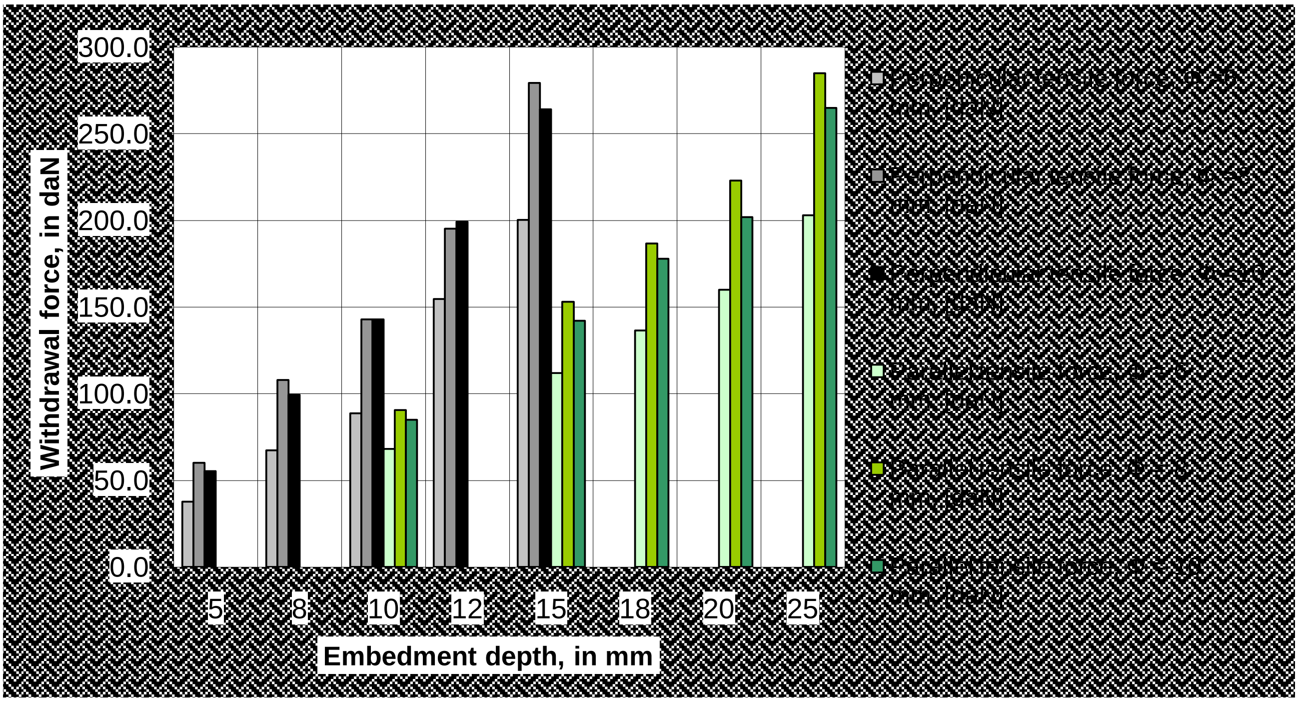


Fig. 6
Withdrawal force for tensile test – comparison.

Regarding the parallel and perpendicular tensile strengths, as a result of the calculation by using the relations (1) and (2), values in the range of 30daN/cm^2 - 80daN/cm^2 have been obtained, higher for the perpendicular strains. The maximum values for both types of strains are shown in Fig. 7.

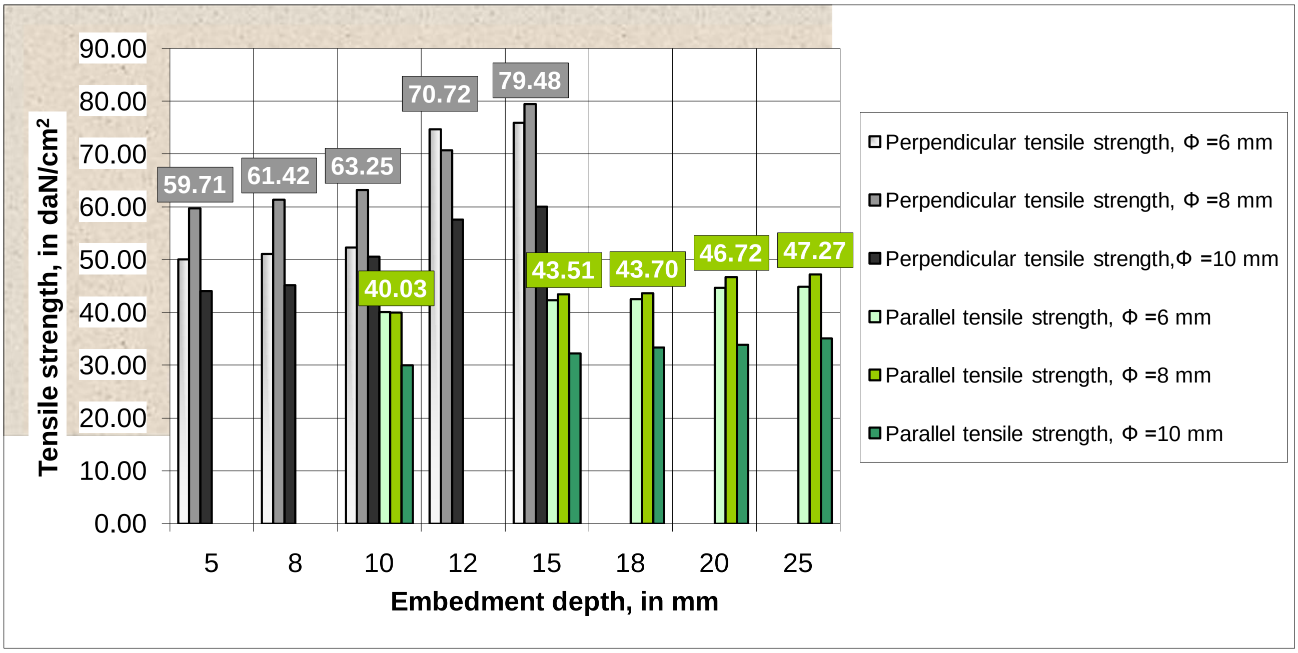


Fig. 7
The measured values of the thermal conductivity coefficient.

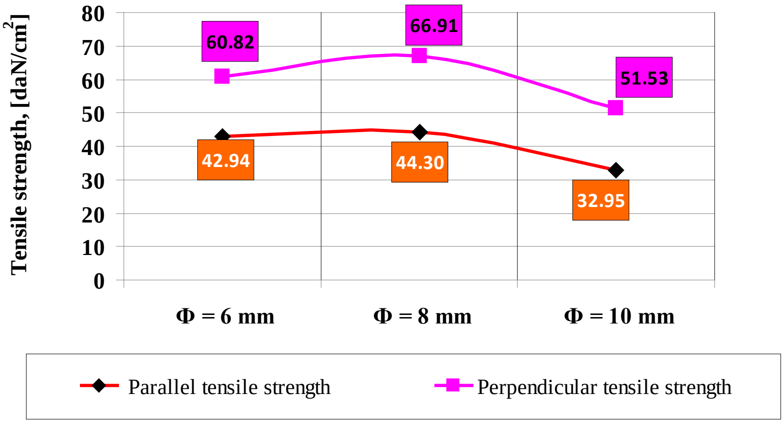


Fig. 8
The mean of the tensile strength values for the three types of dowels.

In Fig. 8 the mean values of the parallel and perpendicular tensile strengths of the three types of analyzed dowel joints: with dowels of Ø=6mm, Ø=8mm and Ø=10mm diameter, are presented. It can be seen that the maximum values for both strains are recorded for the dowel with a diameter of 8mm. The strengths are obviously higher for the perpendicular tensile stresses than for the parallel tensile stresses.

The fracture type of the specimens is also a good indicator of the causes of breaking when applied the tensile strains. Pictures of the way of breaking the specimens during the tests performing, are shown in Fig. 9.

b

a

Fig. 9
Way of breaking the specimens; a – parallel tensile test; b – perpendicular tensile test.

CONCLUSIONS

From the results of the experimental tests it can be concluded that both the withdrawal forces and the tensile strengths (perpendicular and parallel) for the 18mm thick particleboard panels dowel joints have recorded maximum values for the dowels whose diameter was Ø = 8mm.

Although the withdrawal forces that occured in the tensile test, both parallel and perpendicular were higher for the dowels of 10mm diameter than for the dowels of 6mm diameter, however, the calculation of the tensile strengths, where the gluing surface interferes, shows that the tensile strength of the 10mm diameter dowel joint registered the worst values. This can be seen in the fracture way of the specimens, where the 10mm dowel joint specimens have been broken together with the separation of the faces, while the other joints were predominant as withdrawals. This can be explained by the lower resistance of the particleboard in the joint, where the distance from the edge of the hole to the edge of the panel is only of 4mm long.

Therefore, according to the results, it can be said that at the edge to edge joint of the particleboard panels of 18mm thickness, it is recommended to use dowels of 8mm diameter and the embedment depth of 25mm for the joint. For the "L" and "T"-type joints of 18mm particleboard panels, the dowel of 8mm diameter is also recommended for an embedment depth of the dowel of 15mm. For this type of joint, the values of the tensile strengths are quiet satisfactory also for the dowels with a diameter of 6mm and an embedment depth of 15mm.

However, it is not recommended for any of these joints to use dowels of 10mm diameter, which provide poor tensile strengths for these joints.

Knowing from this study the influence of the diameter and of the embedment depth of the dowel upon the joint behaviour, future research can provide information about the influence of the distance between the centers of the dowel holes upon the rigidity of the furniture cases.

ACKNOWLEDGEMENT

The authors hereby express their sincere thanks to Eng. Valeriu BUDULAN, for the support in performing the measurements within this research.

REFERENCES

Curtu I ş.a. (1988) Îmbinări din lemn. Structură, tehnologie, fiabilitate. (Wooden joints. Structure, technology, reliability), Editura Tehnică Bucureşti.

Curtu I, Ghelmeziu N (1984) Mecanica lemnului şi materialelor pe bază de lemn (Mechanics of Wood and Wooden Based Materials), Editura Tehnică Bucureşti.

Kurt Ş, Uysal B, Özcan C, Yildirim MN (2009) The effects of edge banding thickness of uludag fir bended with some adhesives on withdrawal strength of beech dowel pins in composite materials. In BioResources 4(4):1682-1693.

Najafi A (2013) Investigation on the Strength of T-Shape Joint. In Middle-East Journal of Scientific Research 15(3):398-402, ISSN 1990-9233.

Norvydas V, Juodeikienė I, Minelga D (2005) The Influence of Glued Dowel Joints Construction on the Bending Moment Resistance. In Materials Science, 11(1):36-39, ISSN 1392–1320.

STAS 6601-89. Mobilier de lemn. Îmbinarea panourilor din PAL şi plăci aglomerate de fibre de lemn (Wooden furniture. Joining of chipboard and fiberboard panels).

Tankut N (2009) Effect of various factors on the rigidity of furniture cases. In African Journal of Biotechnology, 8(20):5256-5270, ISSN 1684-5315.

Zhang JL, Eckelman CA (1993) The bending moment resistance of single-dowel corner joints in case construction. Forest Products Journal, 43(6):24.