WOOD RESEARCH
56 (4): 2011
601-612

THE EFFECT OF EDGE BANDING THICKNESS OF SOME TREES ON WITHDRAWAL STRENGTH OF BEECH DOWEL PINS IN COMPOSITE MATERIAL

Fatih Yapici, Erkan Likos, Raşit Esen
Karabuk University, Faculty of Technical Education
Karabuk, Turkey

(Received July 2009)

ABSTRACT

Composite materials and wooden dowels are being used increasingly in the construction of furniture frames and inner decoration. Yet there is little information available concerning the withdrawal strength of various fasteners, and, in particular, dowels in composite materials edged solid wood edge bandings. The aim of this study was to determine the withdrawal strengths of 6, 8, 10 mm diameter dowels produced from beech with respect to edge of a medium-density fiberboard (MDF) or particleboard (PB) edged with 5, 10 and 15 mm thickness of solid wood edge banding of scotch pine, oriental beech and lime tree, bonded with hot-melt, poly (vinyl acetate) (PVAc) and Desmodur-VTKA (D-VTKA), a polyurethane based one-component adhesive. The effects of edge banding thickness, dimension of dowels, type of composite materials and type of adhesives used for edge banding on the withdrawal strength were determined. The highest (6.68 $N.mm^{-2}$) withdrawal strength was obtained in beech dowels with 8 mm diameter for MDF with 5 mm thickness of solid wood edge banding of bonded beech with D-VTKA adhesive.

KEYWORDS: PVAc, hot-melt, D-VTKA adhesives, withdrawal strength of dowel, wood composite, wood edge bandings.

INTRODUCTION

The performance and behavior of adhesive systems for wood depend on a wide range of variables, such as smoothness of substrate surfaces, pH, presence of extractives, and amount of debris Pizzi (1983). The bonding mechanism of the adhesive to the wood substrate can include covalent bonding; weaker forces such as van der Waals forces and hydrogen are bonding, or mechanical interlocking (Skeist 1962, Packham 1992).

The strength of the bond between wood fiber and cement determines the composite properties and depends on the wood species, treatment of the fiber, and additives in the mixture

Lee and Hong (1986). Some major parameters that affect fiber interaction with the matrix are the matrix composition (cracked or uncracked), fiber geometry, and fiber type, surface characteristics of the fiber, fiber orientation, fiber volume, and the overall durability of the composite (Balaguru and Shah 1992).

Particleboard historically has been made with forest products. However, due to government restriction; wildlife protection, and other environmental concerns, the availability of these raw materials has been decreasing. The demand for particleboard products continues to increase, leaving an increasing gap between raw materials and products demand (Cheng et al. 2004).

Dowel joints are widely used in furniture frame construction, both as (load-bearing structure) connections and also as simple locators for parts. Joints constructed with dowels may be subjected to withdrawal, bending, shear, and tensional forces. The individual dowel pins used in the joints, however, are subjected to withdrawal and shear forces only (Eckelman and Erdil 1999).

Detailed knowledge of the holding strength of dowels in wood composites and laminated veneer lumber (LVL) is necessary for the rational design of furniture. The face withdrawal strength of plain dowels and spiral-grooved dowels in MDF, OSB (Oriented Strand Board) and PB was studied by (Eckelman and Cassens 1985, Englesson and Osterman 1972). It was reported that plain dowels and spiral-grooved dowels with the fine grooving gave greater withdrawal strength from the face of particleboard than did multi-groove dowels at least when an excess adhesive was applied in the holes and subsequently forced into the substrate as the dowels were inserted into the holes Englesson and Osterman (1972).

Englesson and Osterman (1972) found that applying glue to both the walls of the holes and the sides of the dowels (double gluing) resulted in a 35 % increase in holding strength compared to coating the walls of the holes or sides of the dowels alone. They also found that filling the holes with adhesive so that the glue was forced into the porous surrounding substrate could appreciably increase joint strength.

Bachmann and Hassler (1975) evaluated the withdrawal strength of dowels from both the faces and the edges of several types of particleboards. In general, they found that the withdrawal strength of dowels perpendicular to the face of the board was related to the internal bond strength of the board and the diameter of the dowel.

Zhang and Eckelman (Zhang and Eckelman 1993) reported information on the strength of corner joints constructed with single dowels. The results showed that dowels should be embedded 2 or 2.5 cm thick butt members in order to obtain optimum bending strength.

According to Eckelman (Eckelman 1969) the strength of joints can often be significantly improved through the proper use of an adhesive. Two factors are of interest. First, nominal levels of strength often can be significantly improved through the use of adequate adhesives and proper gluing techniques. Second, research has demonstrated the need to thoroughly cover the walls of dowel holes with adhesive to maximize the connection strength, and the strength of dowel joints can be significantly increased through the use of excess adhesives (Eckelman 1979).

The aim of this study was to determine the connection resistance of dowels produced from beech wood and the effects of thickness, dimension of dowels, type of composite materials (MDF and particleboard) and type of adhesives used for edge banding on the withdrawal strength.

MATERIAL AND METHODS

Wood material

Beech wood (*Fagus orientalis* Lipsky) is used for the production of dowels with 6, 8, 10 mm dimensions, scotch pine (*Pinus sylvestris* L.), oriental beech (*Fagus orientalis* Lipsky) and lime tree (*Tilia perfifolia* Ehrh.) for edge banding with 5, 10, 15 mm thickness. The density of the wood materials used in the study is shown in Tab. 1.

Tab. 1: Wood materials used as raw material.

Wood species	Density r_{12} (g.cm^{-3})	Std. deviation
Beech (*Fagus orientalis* Lipsky)	0.66	.01398
Scotch pine (*Pinus sylvestris* L.)	0.52	.01491
Lime tree (*Tilia perfifolia* Ehrh.)	0.53	.01491

r_{12}=air dry density at 20°C and 65 % relative humidity

Composite material

The following composite test panels were investigated.
An MDF board, produced according to TS EN 622-3 standards, with density 730 kg.m^{-3} was purchased from a local merchant. Pieces measuring 100 x 100 x 18 mm were cut from the panel, which measured 2100 x 2800 x 18 mm TS EN 622-3.

A particleboard produced according to TS EN 312-1 with a density 590 kg.m^{-3}, was purchased from a local merchant. Pieces measuring 100 x 100 x 18 mm were cut from the panel, which measured 2100 x 2800 x 18 mm dimensions (TS EN 312-1).

Adhesives

Poly (vinyl acetate) (PVAc) adhesive is usually preferable for the assembly process in the furniture industry. According to the producer's recommendations, the adhesive was applied in the amount of 180-190 g.m^{-2} to the surfaces. Its viscosity was 16 000 ± 3000 mPa.s at 25°C; density 1.1 ± 0,02 g.ml^{-1} at 20°C and 20 minutes for cold process is recommended at 6-15 % humidity. The TS 3891-1983 standard procedure was used for applying PVAc adhesive, supplied by Polisan, Turkey.

The Producer firm (Producer firm text) describes Desmodur-VTKA as polyurethane based one-component solvent-free adhesive which is widely used for the assembly process in the furniture industry. It is used for gluing wood, metals, polyester, stone, glass, ceramic, PVC and other plastic materials. Its application is specially recommended in locations subjected to high-level humidity. Gluing process was carried out at 20°C and 65 % relative humidity. According to the producer's recommendations, the adhesive was applied in the amount of 180-190 g.m^{-2} to the surfaces. Its viscosity was 14 000 ± 3000 mPa.s at 25 °C, density 1.11 ± 0,02 g.ml^{-1} at 20°C and it showed resistance against the cold air.

The producer firm text describes Hot-Melt as based thermoplastic synthetic resin which is used for adhesive the edge of melamine and polyester materials in the furniture industry. Its application is recommended in location subjected to 8-10 % moisture. Temperature of adhesive gluing was carried out at 200-230°C. Process of speed was carried out at 8-80 m.min^{-1}.

Preparation of test samples

Wood materials were kept in a room at 20 ± 2°C and 65 ± 3 % relative humidity until their weight became stable. Then, 100 x 5 x 18 mm, 100 x 10 x 18 mm and 100 x 15 x 18 mm pieces were cut from oriental beech, scotch pine and lime tree sapwood and each composite material was bonded with PVAc, D-VTKA and Hot-Melt adhesives. For dowels, 1000 x 11 x 11 mm pieces were cut from beech sapwood and dowels having 6, 8 and 10 mm diameter were produced from these pieces using the dowel machines.

Dowel holes for withdrawal tests were drilled to 20 mm depth in the center of one edge of each specimen according to the procedure of TS 4539-1983. All holes were drilled with standard twist drills. The diameter of the holes was 6, 8 and 10 mm. Before the dowels were inserted, PVAc adhesive (180 $g.m^{-2}$) was applied both on their sides and on the hole surfaces. Before the withdrawal test, the samples were stabilized at 20 ± 2°C and at 65 ± 3 % relative humidity to reach 12 % relative humidity at the end of the stabilization.

Test method

All tests were carried out on a universal testing machine with a capacity of 5 kN equipped with jigs to hold the specimens as shown in Fig. 1.

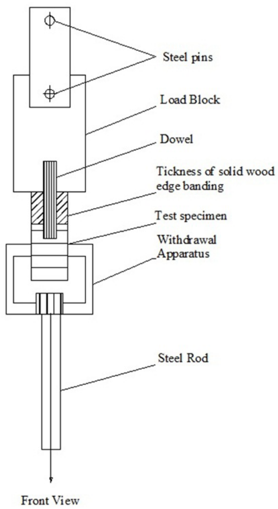

Fig. 1: Apparatus used to hold specimens for testing withdrawal tests.

A loading rate of 5 mm per minute was used in all tests according to ASTM 1037 standard. The loading was continued until separation occurred on the surface of the test samples, regarding to the observed load (F_{max}), bonding surface of sample (A), the withdrawal strength (τ_k) was calculated from equation 1:

$$\tau_k = \frac{F\max}{A} = \frac{F\max}{h(2\pi r)} \qquad (1)$$

where: τ_k= withdrawal strength ($N.mm^{-2}$), r = radius of dowel (mm), h = depth of dowel embedded in the face member (mm).

Data Analyses

By using two different kinds of composite materials, three different diameters of dowels, three different thickness of solid wood edge banding, three different trees of solid wood edge banding and three different types of adhesives as parameters, a total of 1680 samples (2 x 3 x 3 x 3 x 3 x 10 + 60 control) were prepared, with ten samples for each parameter. Multiple variance analyses were used for determining the differences between the groups afterwards the Duncan test was executed to determine whether the differences had any significant levels (Unver 1992).

RESULTS AND DISCUSSION

The average withdrawal strength values obtained from the test samples are given in Tab. 2, the average values of interactions between the factors are presented in Tab. 3, and the results of the multiple variance analyses connected with these values are shown in Tab. 4.

Tab. 2: The average values of withdrawal strength.

Factor source		Withdrawal strength (N.mm^{-2})	Std. deviation
Composite material	Particleboard	4.594	0.17
	MDF	4.944	0.18
Thickness of massive	5 mm	4.724	0.13
	10 mm	5.131	0.15
	15 mm	4.796	0.19
	Control	3.732	0.10
Dowel of diameter (mm)	6	4.967	0.12
	8	4.884	0.15
	10	4.455	0.1
Adhesive type	PVAc	4.830	0.17
	D-VTKA	4.769	0.15
	Hot-Melt	4.707	0.2
Solid wood edge banding	Pine	4.746	0.15
	Beech	5.158	0.13
	Lime tree	4.748	0.18
	Control	3.732	0.21

The highest withdrawal strength value was obtained with MDF as the composite material, PVAc as the adhesive, and 10 mm as thickness and beech of solid wood edge banding and 6 mm as dowel diameter.

According to the interaction of the average values obtained from the factors (type of adhesive, composite material, thickness of solid wood edge banding, dowel of diameter), 8 mm diameter of dowel and 5 mm thickness and beech of solid wood edge banding gave the highest withdrawal strength value (6.689 N.mm^{-2}) for the MDF with Hot-melt adhesive. Comparing particleboard with MDF, particleboard had poor results when determining withdrawal strength of dowel.

Tab. 3: The average values of interaction (N.mm⁻²).

Solid wood edge banding	Thickness massive ↓	Adhesives ↓	Composite material					
			Particleboard			MDF		
			Diameter of dowel (mm)					
			6	8	10	6	8	10
Pine	5 mm	Hot-Melt	4.818	3.951	4.630	4.758	4.742	4.617
		PVAc	4.968	4.467	4.280	4.573	5.398	4.417
		D-VTKA	4.978	3.903	3.395	5.518	5.034	4.346
	10 mm	Hot-Melt	5.566	5.559	5.383	4.458	4.875	3.957
		PVAc	5.800	4.600	4.689	4.960	6.107	5.643
		D-VTKA	5.552	4.543	3.747	5.059	4.641	3.930
	15 mm	Hot-Melt	5.718	4.230	4.681	3.904	5.493	3.897
		PVAc	5.388	5.168	4.480	5.870	5.008	4.116
		D-VTKA	5.288	3.993	3.300	5.372	4.106	4.408
	Control	Control	3.431	2.834	2.696	4.374	4.363	4.695
Beech	5 mm	Hot-Melt	4.241	4.208	4.028	3.453	6.689	5.597
		PVAc	4.948	3.757	3.349	5.132	5.462	4.073
		D-VTKA	5.595	3.918	4.488	5.961	5.684	5.783
	10 mm	Hot-Melt	6.193	5.277	4.811	5.608	5.181	5.037
		PVAc	5.320	4.599	5.515	5.846	5.680	5.765
		D-VTKA	6.104	5.933	5.783	5.445	5.153	5.137
	15 mm	Hot-Melt	5.414	5.302	3.992	4.990	5.726	4.116
		PVAc	4.768	5.354	5.526	5.295	6.309	5.642
		D-VTKA	4.613	5.611	5.324	6.086	4.839	4.853
	Control	Control	3.431	2.834	2.696	4.374	4.363	4.695
Lime tree	5 mm	Hot-Melt	5.178	5.561	4.295	2.731	5.890	4.867
		PVAc	3.779	4.852	3.293	5.198	5.478	4.417
		D-VTKA	5.343	4.251	4.367	5.182	5.990	5.243
	10 mm	Hot-Melt	5.352	5.188	5.492	4.243	5.596	4.931
		PVAc	5.171	5.536	4.215	5.210	5.962	4.727
		D-VTKA	5.660	4.438	3.490	5.482	5.139	3.810
	15 mm	Hot-Melt	4.364	4.901	4.668	4.666	4.289	2.741
		PVAc	5.192	4.554	3.936	4.980	4.444	4.176
		D-VTKA	4.653	3.928	3.842	4.670	4.936	5.882
	Control	Control	3.431	2.834	2.696	4.374	4.363	4.695

Tab. 4: The results of the multiple variance analyses.

Source of variance	Sum of squares	Degrees of freedom	Mean square	F value	P sig.
Corrected Model	1224.349	179	6.840	71.902	.000
Intercept	34567.027	1	34567.027	363369.544	.000
Factor A	51.113	2	25.557	268.651	.000
Factor B	3.107	2	1.554	16.332	.000
Factor C	93.776	1	93.776	985.774	.000
Factor D	66.424	2	33.212	349.127	.000
Factor E	60.730	2	30.365	319.198	.000
A * B	35.183	4	8.796	92.461	.000
A * C	37.796	2	18.898	198.656	.000
B * C	24.863	2	12.431	130.679	.000
A * B * C	14.034	4	3.509	36.882	.000
A * D	7.098	4	1.775	18.654	.000
B * D	28.318	4	7.079	74.419	.000
A * B * D	42.292	8	5.287	55.572	.000
C * D	41.853	2	20.926	219.980	.000
A * C * D	19.409	4	4.852	51.008	.000
B * C * D	8.546	4	2.137	22.460	.000
A * B * C * D	17.574	8	2.197	23.092	.000
A * E	23.312	4	5.828	61.265	.000
B * E	29.010	4	7.253	76.239	.000
A * B * E	11.068	8	1.383	14.543	.000
C * E	6.714	2	3.357	35.287	.000
A * C * E	6.234	4	1.559	16.383	.000
B * C * E	24.267	4	6.067	63.775	.000
A * B * C * E	18.083	8	2.260	23.761	.000
D * E	21.896	4	5.474	57.544	.000
A * D * E	27.499	8	3.437	36.133	.000
B * D * E	20.650	8	2.581	27.134	.000
A * B * D * E	66.292	16	4.143	43.554	.000
C * D * E	2.280	4	0.570	5.992	.000
A * C * D * E	14.860	8	1.857	19.526	.000
B * C * D * E	23.686	8	2.961	31.123	.000
A * B * C * D * E	52.412	16	3.276	34.435	.000
Error	154.109	1620	9.513E-02		
Total	42318.291	1800			
Corrected Total	1378.459	1799			

Factor A = Thickness of solid wood edge banding
Factor B = Type of adhesives
Factor C = Composite material (Particleboard, MDF),
Factor D = Diameter of dowel
Factor E = Solid wood edge banding
F value = The F statistic is calculated by dividing the mean square by the mean square error.

The difference between the groups regarding to the effect of variance sources on withdrawal strength was meaningful (α = 5 %). The results of the Duncan test conducted to determine the importance of the differences between the groups are given in Tab. 5.

Tab.5: The results from the Duncan test (N.mm^{-2}).

Source of variance	**X**	**HG**	**Source of variance**	**X**	**HG**
K-P-3	2.696	a	II-H-M-1-Pine	5.608	hıjk
I-H-M-1-Lime tree	2.731	a	III-V-P-2-Beech	5.611	hıjk
III-H-M-3-Lime tree	2.741	a	III-P-M-3-Beech	5.642	hıjkl
K-P-2	2.834	a	II-P-M-3-Pine	5.643	hıjkl
I-P-P-3 Lime tree	3.293	b	II-V-P-1- Lime tree	5.660	hıjklm
III-V-P-3 Pine	3.300	b	II-P-M-2-Beech	5.680	hıjklm
I-P-P-3-Beech	3.349	b	I-V-M-2-Beech	5.684	hıjklm
I-V-P-3-Pine	3.395	b	III-H-P-1-Pine	5.718	hıjklm
K-P-1	3.431	b	III-H-M-2-Beech	5.726	hıjklm
II-V-P-3-Lime tree	3.490	bc	II-P-M-3-Beech	5.765	hıjklmn
I-H-M-Beech	3.558	bcd	II-V-P-3-Beech	5.783	hıjklmno
II-V-P-3-Pine	3.747	cde	I-V-M-3-Beech	5.783	hıjklmno
I-P-P-2-Beech	3.757	cde	II-P-P-1-Pine	5.800	hıjklmno
I-P-P-1-Lime tree	3.779	cdef	II-P-M-1-Beech	5.846	hıjklmno
II-V-M-3- Lime tree	3.810	defg	III-P-M-1-Pine	5.870	ıjklmno
III-V-P-3- Lime tree	3.842	defg	III-V-M-1-Pine	5.882	jklmnop
II-P-P-3-Beech	5.515	h	I-H-M-3-Pine	5.890	jklmnop
I-V-M-1-Pine	5.518	h	II-V-P-2-Beech	5.933	klmnop
III-P-P-3-Beech	5.526	h	I-V-M-1-Beech	5.961	lmnop
II-P-P-2- Lime tree	5.536	hı	II-P-M-2- Lime tree	5.962	lmnop
II-V-P-1-Pine	5.552	hıj	I-V-M-2- Lime tree	5.990	mnop
II-H-P-2-Pine	5.559	hıj	III-V-M-1-Beech	6.086	nopr
I-H-P-2- Lime tree	5.561	hıj	II-V-P-1-Beech	6.104	prs
II-H-P-1-Pine	5.566	hıj	II-P-M-2-Pine	6.107	prs
I-V-P-1-Beech	5.595	hıj	II-H-P-1-Beech	6.193	rs
II-H-M-2- Lime tree	5.596	hıj	III-P-P-2-Beech	6.309	r
I-H-M-3-Beech	5.597	hıj	I-H-M-2-Beech	6.689	s

Thickness of solid wood edge banding; I= 5 (mm), II= 10 (mm), III= 15 (mm), K= Control
Type of adhesives; H= Hot-Melt, P= PVAc, V= D-VTKA
Composite material; P= Particleboard, M= MDF
Diameter of dowel; 1= 6 mm, 2= 8 mm, 3= 10 mm

Interactions between adhesive type and thickness of solid wood edge banding, diameter of dowel, solid wood edge banding and composite material are given Figs. 2, 3, 4, 5.

In respect of composite material, Eckelman and Cassens (1985) showed that, in general, the holding strength of both MDF and particleboard could be predicted from the following theoretical expression.

$$F_2(\text{face}) = (IB)\,L\ ,\ F_2(\text{edge}) = (IB)\,L \quad (2)$$

where: F_2 is the withdrawal strength (N.mm^{-2}) of the dowel from face or edge, IB is the internal bond strength of the composite (N), and L is the depth of embedded dowel (mm).

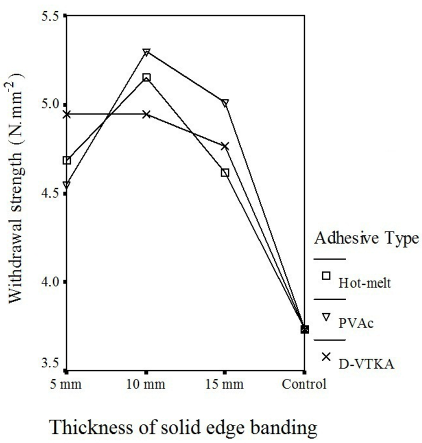

Fig. 2: *Effect of types of adhesives and thickness of solid wood edge banding on withdrawal strength.*

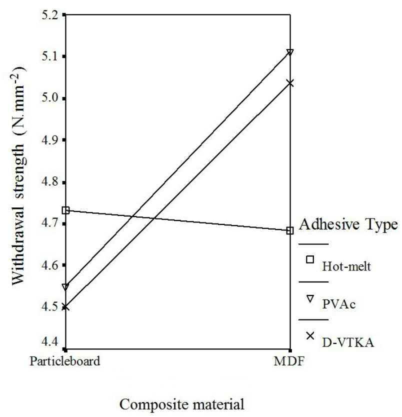

Fig. 3: *Effect of types of adhesives and composite materials on withdrawal strength.*

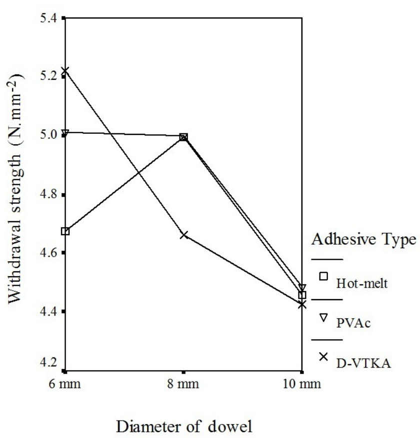

Fig. 4: *Effect of types of adhesives and diameter of dowels on withdrawal strength.*

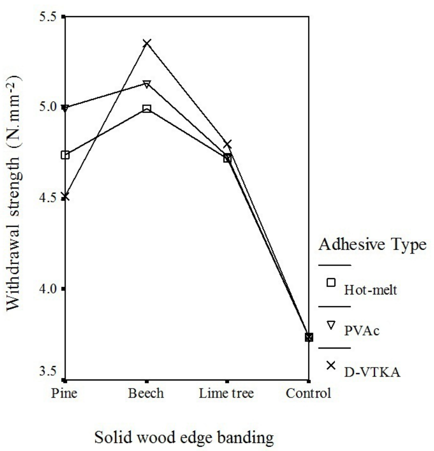

Fig. 5: *Effect of types of adhesives and solid wood edge banding on withdrawal strength.*

The results of this study showed that there was a close linear relationship between predicted values and test results. However, this relationship did not bear for the adhesives tested in the same study. The highest withdrawal strength was obtained in MDF with 8 mm diameter of dowel and 5 mm thickness and beech of solid wood edge banding Hot-melt adhesive while the lowest withdrawal strength was obtained in particleboard with 10 mm diameter of dowel and without solid wood edge banding.

CONCLUSIONS

The withdrawal strength of dowels from the edges of MDF and particleboard is likely to be a function of the mechanical properties of the base material, the process variables involved in the manufacture of the board, and the geometry of the particles or layers of the board. Better results were obtained with MDF than with particleboard because of the higher density and more homogeneous structure of MDF. This gives a smooth hole in the drilling process and smooth surfaces increase the bonding strength.

According to results, if the whole wall and the surface of dowel are smooth then the adhesives give better mechanical adhesion with dowels and composite materials. Moreover, if the dowels are subject to withdrawal strength, it is advised that beech dowel should be used on MDF with Hot-melt as the adhesive in furniture production and decoration application.

REFERENCES

1. ASTM-D 1037, 1988: Standard test methods for evaluating the properties of wood-based fiber and particle panel materials.
2. Bachmann, G., Hassler, W., 1975: The strength of various furniture construction, their elements and connections. Holztechnologie 16(4): 210-221.
3. Balaguru, P.N., Shah, S.P., 1992: Fiber reinforced cement composites. McGraw-Hill, New York, 530 pp.
4. Cheng, E., Sun, X., Karr, G.S., 2004: Adhesive properties of modified soybean flour in wheat straw particleboard. Composites Part A: Applied Science and Manufacturing 35(3): 297-302.
5. Eckelman, C.A., 1969: Engineering concepts of single-pin dowel joint design. Forest Products Journal 19(12): 52-60.
6. Eckelman, C.A., 1979 : Out of plane strength and stiffness of dowel joints. Forest Products Journal 29(8): 32-38.
7. Eckelman, C.A., Cassens, L., 1985: Withdraval strength of dowels from wood composites. Forest Products Journal 35(5): 55-60.
8. Eckelman, C.A., Erdil, Z., 1999: Joint design manual for furniture frames constructed of plywood and oriented strand board. 1st International Furniture Congress Proceedings, October 14-17, Istanbul, Pp 266-268.
9. Englesson, T.A., Osterman, A., 1972: Assembly of chipboard with round dowels. Swedish Forest Products Reseach Laboratory, Stockholm, Report No. 28.
10. Lee, A.W.C., Hong, Z., 1986: Compressive strength of cylindrical samples as an indicator of wood– cement compatibility. For. Prod. J. 36(11/12): 87-90.
11. Packham, D.E., 1992: Hand book of adhesion. Vol. 407, 1st ed. Longman. London.
12. Pizzi, A., 1983: Wood adhesives, chemistry and technology. Marcel Dekker Inc., New York, 409 pp.
13. Producer Firm Text, http://www.polisan.com.tr/.
14. Producer Firm Text, Sentez Chemical Industry, Gebze, Kocaeli.
15. Skeist, I., 1962: Handbook of adhesives. Vol. 669, 1st ed. Van Nostrand Reinhold Company, New York.
16. TS EN 622-3, 1999: Fiber boards and their characteristics.
17. TS EN 312-1, 1999: Particleboards – general characteristics.

18. TS 3891, 1983: Adhesives. Polyvinyl acetate emulsion.
19. TS 4539, 1983: Wood joints-the rule of dowel joints.
20. Unver, Ö., 1992: Applied statistics methods. Gazi University, Ankara, 123. Pp 102-107.
21. Zhang, J.L., Eckelman, C.A., 1993: Racional design of multi-dowels cornen joints in case contruction. Forest Products Journal 43(1/2): 52-58.

Fatih Yapici, Erkan Likos, Raşit Esen
Karabuk University
Faculty of Technical Education
78050 Karabuk
Turkey
Corresponding author: fyapici@karabuk.edu.tr