Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 9 (22): 4061-4065, 2009
ISSN 1812-5654

Determination of Bending Strength Elongation in Bending Screw Withdrawal Strength and Swelling in Thickness of Some Panels

M.H. Çolakoğlu
KOSGEB, Abdülhakhamit Caddesi No. 866, 06470, Mamak, Ankara, Turkey

Abstract: This study is conducted to determine and compare some physical and mechanical properties of different panels being used in furniture industry. For this aim, test samples from plastic-based new wood and wood-based particleboard and MDF panels are prepared according to TS EN 326-1. The bending strength and elongation in bending is measured according to TSE EN 310, screw withdrawal strength according to TS EN 320 and swelling in thickness according to TS EN 317. As a result, the strength in bending was the highest in MDF (877.0 N mm^{-2}) and the lowest in particle board (542.8 N mm^{-2}). The elongation in bending was the highest in new wood (34.01 mm) and the lowest in particle board (5.65 mm). The screw withdrawal strength was the highest in MDF (822.48 N mm^{-2}) and the lowest in new wood (632.47 N mm^{-2}). Swelling in thickness due to water absorption was the highest in particle board (4.44 mm) and the lowest in new wood (0.02). According to these results, water absorption was the lowest but elongation in bending was the highest in new wood. These properties must be taken into account in the selection of material at design.

Key words: MDF, particle board, new wood, elongation in bending, screw withdrawal strength, swelling

INTRODUCTION

Furniture used at home or offices are subject to direct or indirect forces. Those forces exist as a tension or compression stress at the furniture elements and connection points, causing to deformations like bending, crack or openings. Different types of construction are used to overcome those disadvantages (Eckelman, 1974).

In box type furniture biscuit joints, pin and dowel joints, lap joints and screw joints are used at corner conjunctions.

In a study, laminated particle boards are tested for three different types of screw which are applied parallel to surface. The highest strength was measured in the particle boards where side surfaces of plates were coated with massive wood. It was reported that the application of adhesive to the pilot holes increased the screw withdrawal strength (Doganay *et al*., 1997).

In another study, the screw withdrawal strength vertical to surface of three different types of screws are searched for particle board, MDF, Werzalit and beech wood. It was the highest in beech wood vertical to fibers followed by Werzalit, MDF and particle board. For different types of screw, the highest strength was measured with small dimension screws called as 17×17 and 18×25 (Örs *et al*., 1995).

In L-type corner connections of particle boards and MDF, the bending strength was increased with the area of connection so that the length of screw was much more important than the diameter (Wan-Qian and Eckelman, 1993).

In a study about the design stress and fatigue life of wood composites, MDF (Medium Density Fiberboard), OSB (Oriented Strand Board) and particle board are tested in diagonal direction. It is determined that as the stress level increases, fatigue life decreases (Bao and Eckelman, 1995).

In the production of particle board, the usage of different wood types cause to an increase in thickness by water absorption but to a decrease in modulus of elasticity, maximum bending strength and screw withdrawal strength vertical to the surface (Gündüz and Yılmaz, 2005).

In this study bending strength, elongation in bending, screw withdrawal strength and swelling in thickness by water absorption is measured for 18 mm thickness MDF, particle board and new wood plates.

MATERIALS AND METHODS

This study, was conducted at Gazi University Furniture and Decoration Department Laboratory. The materials used in this research and the method are explained below. These materials are obtained from the industry in Ankara.

Melamine-coated particle board: Test samples are prepared according to EN 312 (2003) from 18 mm thickness melamine-coated particleboard. Its density is 0.68 g cm^{-3}, humidity 7% and modulus of elasticity 18.000 kg m^{-2} according to ASTM D 1037 (1999).

Medium density fiber board: Fiberboards may be soft, medium or hard and have surfaces with different characters. The disadvantages like knot, rottenness, spiral or cross-grained fiber, crack formation do not exist in fiber boards. MDF is produced according to EN 64-3; EN 622-3, (2004) in dimension of 183×366 cm at 3-32 mm in thickness. Its density is 0.72 g cm^{-3}, humidity is 9% and modulus of elasticity is 60.000 kg m^{-2} according to ASTM D 1037 (1999).

New wood: In bath and kitchen furniture, esthetic and life are very important factors to be taken into care at design. New wood made of polystyrene material is not a carcinogen, do not contaminate any bacterium, has a long life, easy to clean, resistant to water and moisture effects. New wood is produced in thickness 8 to 18 mm with a dimension of 90×280 cm. It can be painted and easily machined. In other words, all kind of machining processes applied to particle board can be also applied to new wood panels. Because of its high moisture resistance, this material can be used in the production of box type furniture and door to be used in bath, toilet, kitchen etc., at hospitals, hotels and holiday places as explained in new wood product brochure.

Its density is 0.493 g cm^{-3}, humidity 0% and modulus of elasticity 761 N mm^{-2} according to ASTM D 1037 (1999).

Screw: The screw used in tests is defined as 4.2×38 mm, galvanized and called as ST 4.2 according to TS 432-1 EN ISO 1478 (2000) (Fig. 1).

Preparation of test samples: Eight test samples for each test are prepared in accordance with EN 326-1 (1994). For bending strength and elongation in bending tests, the samples with a dimension of 50×410 mm and 18 mm in thickness are prepared. Test samples for screw withdrawal strength test are in rectangular shape with a dimension of 75 mm. For swelling in thickness test, the samples are prepared with a dimension of 50±1 mm in rectangular shape. Test samples are conditioned at 65±3% relative humidity and 20±2°C temperature conditions up to reaching to a stable state according to EN 326-1 (1994).

Conduction of tests

Bending strength and elongation in bending test: The bending strength and elongation in bending were measured with a testing machine shown in Fig. 2 according to EN 310 (1993).

Computer controlled bending test machine with a capacity of 1,000 kf reaches to the highest force in 1-2 min at a speed 5 mm min^{-1}. The maximum force in bending is calculated by the following formula:

$$\sigma_e = \frac{3F\max l}{2bt^2} \quad (1)$$

Where:

σ_e = Bending strength (N mm^{-2})
l = Distance between the standing points (mm)
b = Width of sample (mm)
t = Thickness of sample (mm)

Screw withdrawal test: Screw withdrawal testing was conducted with the testing machine shown in Fig. 3 at Gazi University Technical Education Faculty Laboratory according to EN 320 (1999).

F_{max} is reached in 60±30 sec and registered with 1% tolerance. The screw withdrawal strength is calculated by the following formula:

$$f = \frac{F_{max}}{d l_p} \quad (2)$$

Where:

f = Screw withdrawal capacity (N mm^{-2})
F_{max} = The highest withdrawal force (N)
l_p = Depth of screw in board (mm)
d = Screw diameter (mm)

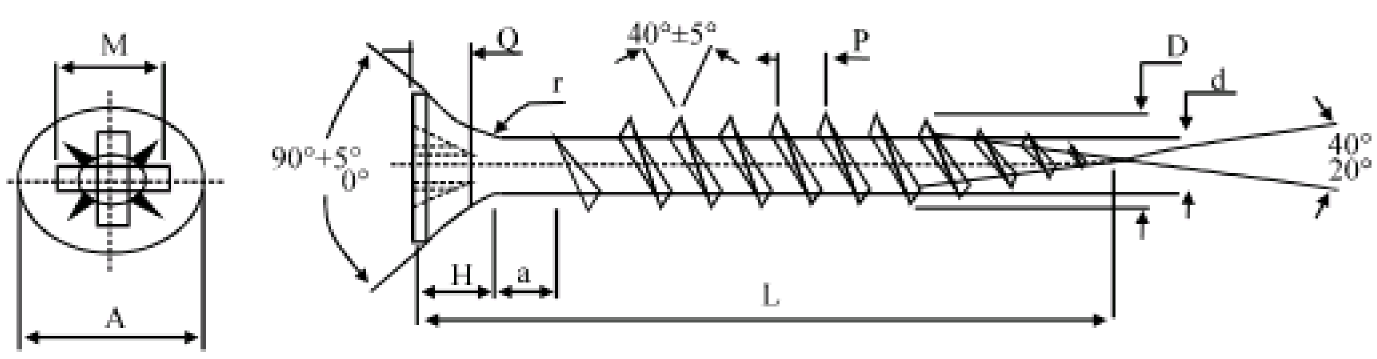

Fig. 1: Screw dimensions

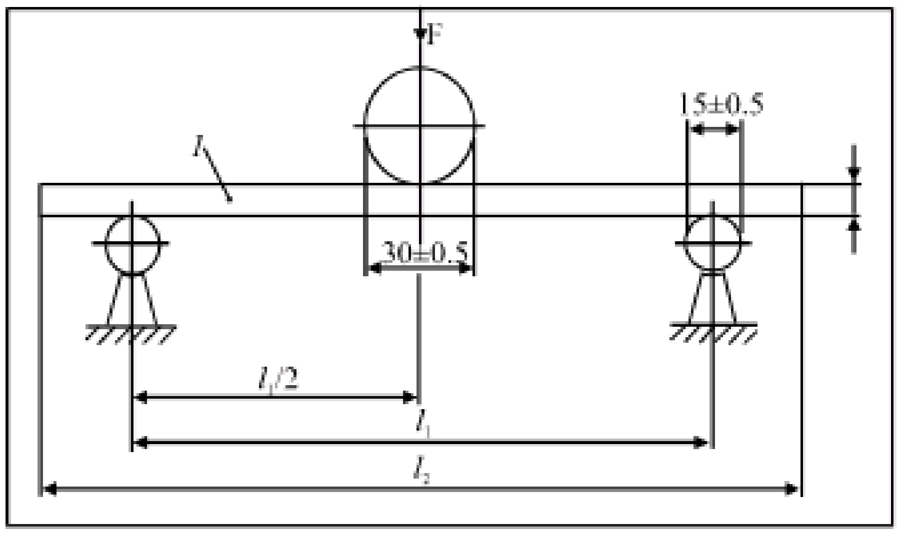

Fig. 2: Bending test machine (mm)

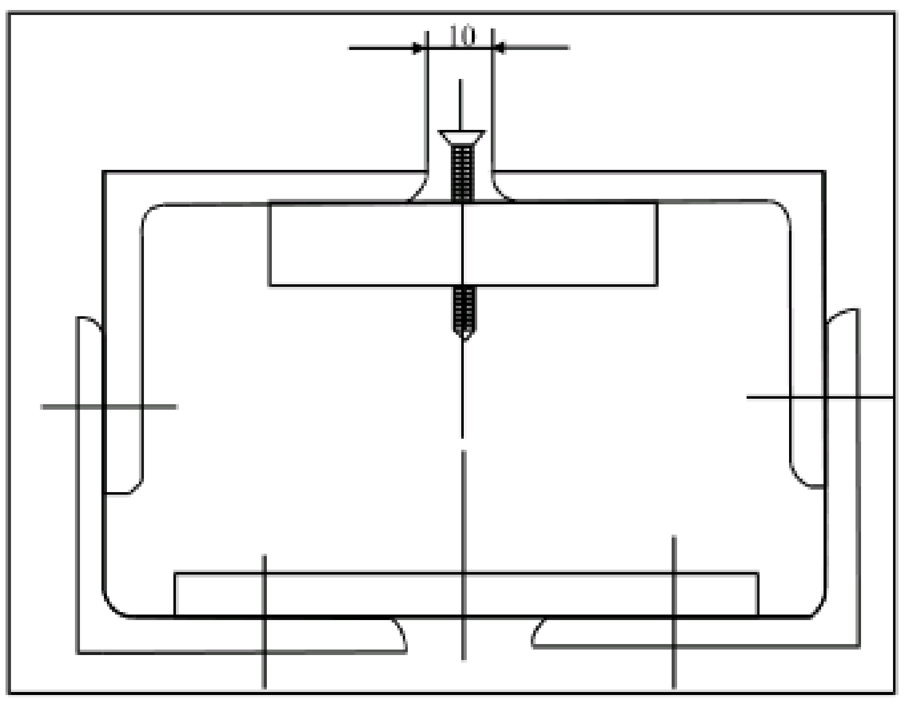

Fig. 3: Screw withdrawal testing vertical to surface

Swelling in thickness: The swelling in thickness of test samples, prepared according to EN 325 (1993) was measured according to EN 317 (1999). For this aim, the water with a temperature 20±1°C and pH 7±1 was used. The samples were placed 25±5 mm below the water surface so that not touching to container base or to each other. They were kept in water up to reaching a stable weight and the dimensions were measured with micrometer 0.01 mm in tolerance.

Evaluation of the results: Multiple variance analysis was conducted to understand the impact of material type on bending strength, elongation in bending, screw withdrawal strength and swelling in thickness.

RESULTS

Bending strength: Bending strength was measured as the highest in MDF and the lowest in particle board. The test results and the multiple variance analysis for the impact of material type on bending strength is given in Table 1 and 2. The literature about MDF and particle board supports these results. The results show that the bending strength of new wood is higher than particle board but less than MDF.

Table 1: Bending strength of materials (kg)

MDF	Particle board	New wood
90.98	49.71	52.53
83.48	55.34	57.22
87.23	55.34	51.59
90.98	53.46	55.34
90.98	59.09	56.90
88.17	60.97	55.34
89.11	48.77	54.40
80.66	51.59	57.22

Table 2: Multiple variance analysis for the impact of material on bending strength

Source of variance	df	Sum of squares	Mean square	F-value	α<0.05
Replication	2	5818.601	2909.300	233.1700	0.0000
Factor A	7	88.438	12.634	1.0126	0.4632
Error	14	174.680	12.477		
Total	23	6081.719			

Factor A: Type of material

Table 3: Mean values of bending strength (N mm^{-2})

Material	X	HG*
MDF	877.0	A
Particle board	542.8	B
New wood	550.7	B

X: Mean value, *Homogeneity group: 3.65

Table 4: Elongation in bending of materials (mm)

MDF	Particle board	New wood
8.78	5.35	31.35
8.42	5.10	38.88
9.05	5.20	37.62
9.00	5.65	31.85
8.27	5.50	30.80
8.87	5.80	38.47
8.88	6.05	31.10
8.10	6.53	32.02

Impact of material type on bending strength was found meaningful statistically (α = 0.05). Duncan test is applied to determine the difference between the groups. The mean values of bending strength for different materials are given in Table 3.

As shown in Table 3 the highest bending strength was measured in MDF (877.0 N mm^{-2}) and the lowest in particle board (542.8 N mm^{-2}).

Elongation in bending: The test results and the multiple variance analysis for the impact of material type on elongation in bending is given at Table 4 and 5. The literature about MDF and particle board supports these results. The results show that the elongation in bending of new wood is higher than MDF and Particle board.

Impact of material type on elongation in bending was found meaningful statistically (α = 0.05). Duncan test is applied to determine the difference between the groups. The mean values of elongation in bending for different materials are given in Table 6.

Table 5: Multiple variance analysis for impact of material on elongation in bending

Source of variance	df	Sum of squares	Mean square	F-value	α<0.05
Replication	2	3882.029	1941.015	418.4896	0.0000
Factor A	7	28.651	4.093	0.8825	
Error	14	64.934	4.638		
Total	23	3975.615			

Factor A: Type of material

Table 6: Mean values of elongation in bending (mm)

Material	X	HG*
MDF	8.67	B
Particle board	5.65	C
New wood	34.01	A

X: Mean value, * Homogeneity group: 2.23

Table 7: Screw withdrawal strength of materials (kg mm^{-2})

MDF	Particle board	New wood
755.06	686.42	647.20
843.32	657.00	725.64
774.67	686.42	578.55
911.96	715.84	558.94
686.42	598.17	715.84
833.51	687.02	578.42
911.96	804.09	578.55
862.93	657.00	676.61

Table 8: Multiple variance analysis for impact of material on screw withdrawal strength

Source of variance	df	Sum of squares	Mean square	F-value	α<0.05
Replication	2	153860.068	76930.034	14.0153	0.0005
Factor A	7	23204.917	3314.988	0.6039	
Error	14	76846.122	5489.009		
Total	23	253911.107			

Factor A: Type of material

Table 9: Mean values of screw withdrawal strength (N mm^{-2})

Material	X	HG*
MDF	822.48	A
Particle board	686.50	B
New wood	632.47	B

X: Mean value, *Homogeneity group: 76.63

As shown in Table 6, the highest elongation was measured in new wood (34.02 mm) and the lowest in (5.65 mm).

Screw withdrawal strength: The result of multiple variance analysis for impact of material type on screw withdrawal strength is given in Table 7 and 8. The literature about MDF and Particle board supports these results.

The impact of material type on screw withdrawal strength was found statistically meaningful (α = 0.05). Duncan test is applied to find the difference between the groups and the mean values of screw withdrawal strength are given in Table 9.

The highest value was found in MDF (822.48 kg mm^{-2}) and the lowest in new wood (632.47 kg mm^{-2}) as shown in Table 9.

Table 10: Swelling in thickness of materials (mm)

MDF	Particle board	New wood
2.86	4.65	0.02
2.82	4.16	0.03
2.93	4.47	0.02
2.82	4.36	0.02
2.81	4.58	0.05
2.75	4.59	0.01
2.88	4.32	0.02
2.9	4.41	0.01

Table 11: Multiple variance analysis for the impact of material on swelling in thickness

Source of variance	df	Sum of squares	Mean square	F-value	α<0.05
Replication	2	72.644	36.322	2080.6403	0.0000
Factor A	7	0.090	0.013	0.7403	
Error	14	0.244	0.017		
Total	23	72.978			

Factor A: Type of material

Table 12: Mean values of swelling in thickness by water absorption

Material	X	HG*
MDF	2.85	B
Particle board	4.44	A
New wood	0.02	C

X: Mean value, *Homogeneity group: 0.1349

Swelling in thickness by water absorption: The test results and the multiple variance analysis for the impact of material type on swelling in thickness by water absorption is given in Table 10 and 11. Provide significant results rather than captions.

The impact of material type on swelling in thickness is found statistically meaningful (α = 0.05). Duncan test is applied to find the difference between the groups and the mean values are given in Table 12.

The highest swelling in thickness was measured in particle board (4.44 mm) and the lowest in new wood (0.02 mm) as shown in Table 12.

DISCUSSION

According to the test results, the bending strength was the highest in MDF (877.0 N mm^{-2}), followed by new wood (550.7 N mm^{-2}) and the lowest in particle board (542.8 N mm^{-2}). Bending strength of MDF is 59 % higher than new wood and 61% than particle board. This case may depend on the fiber structure of MDF.

Elongation in bending was the highest in new wood (34.01 mm), followed by MDF (8.67 mm) and the lowest in particle board (5.65 mm). Elongation in new wood was 292% higher than MDF and 501% than particle board. This case may depend on the plastic material of new wood.

Screw withdrawal strength was the highest in MDF (822.48 N mm^{-2}), followed by particle board (686.50 N mm^{-2}) and the lowest in new wood

(632.47 N mm^{-2}). Screw withdrawal strength of MDF was 30% higher than new wood and 20% higher than particle board. This case may depend on the micro structure of materials.

Swelling in thickness by water absorption was the highest in particle board (4.44 mm), followed by MDF (2.85 mm) and the lowest in new wood (0.02 mm). Swelling in thickness in particle board was 22,100% higher than new wood and 56% than MDF. This case may depend on the polystyrene material of new wood with no porosity.

As a result, new wood has a bending strength less than MDF but higher than particle board. New wood has a high elongation in bending but has a good performance in screw withdrawal strength. In screw connection of panels at box type furniture production, new wood can be used very successfully. Swelling in thickness in new wood is negligible. So, new wood panels can be used successfully under wet conditions. As a conclusion, new wood panels can be used as a material in box type furniture and doors under high humidity conditions with its long life and esthetic properties.

REFERENCES

ASTM D 1037, 1999. Standard methods of evaluating the properties of wood-based fiber and particle panel materials, ASTM. http://www.astm.org/Standards/D1037.htm.

Bao, Z. and C.A. Eckelman, 1995. Fatigue life and design stresses for wood composites used in furniture. Forest Products J., 45: 59-63.

Doganay, S., A. Ozcifci and I. Küreli, 1997. Impact of side coating with massive wood of particleboard on screw withdrawal strength. Gazi Univ. Sci. J., 10: 273-280.

EN 310, 1993. Wood-based panels determination of modulus of elasticity in bending and of bending strength. The European Committee for Standardization.

EN 325, 1993. Wood-based panels determination of dimension of test pieces. The European Committee for Standardization.

EN 326-1, 1994. Wood-based panels sampling, cutting and inspection Part 1- Sampling and cutting of test pieces and expression of test results. The European Committee for Standardization.

EN 317, 1999. Particleboards and fiberboards: Determination of swelling in thickness after immersion in water. The European Committee for Standardization.

EN 320, 1999. Fiberboards determination of resistance to axial withdrawal of screws. The European Committee for Standardization.

EN 312, 2003. Particle boards-general properties. The European Committee for Standardization.

EN 622-3, 2004. Fiber boards specifications: Part 3, requirements for medium boards. The European Committee for Standardization.

Eckelman, C.A., 1974. Reasonable Design Stresses for Woods Used in Furniture. Purdue University Agriculture Exp. Sta. Research, Idiana, pp: 7-8.

Gündüz, G. and Z.A. Yılmaz, 2005. Technological properties of particle boards produced in 16 different plants in Turkey. Zonguldak Karaelmas Univ. J. Bartın Forestry Fac., 2: 49-57.

Örs, Y., R. Özen and S. Doğanay, 1995. Lecture Notes on Screw Withdrawal Strength of some Used in Furniture Production. 95th Edn., Gazi University Technical Education Faculty, Turkey.

TS 432-1 EN ISO 1478, 2000. Tapping screws thread. Turkish Standards Institute.

Wan-Qian and C.A. Eckelman, 1993. Effect of number of fasteners on the strength of corner joints for cases. Forest Product J., 48: 93-95.