https://doi.org/10.17306/mk.978-83-67112-51-2.14

The effect of screw and adhesive type on screw direct withdrawal resistance in plywood, particleboard and MDF

Emre Birinci✉

[1]Kastamonu University, Faculty of Forestry, Department of Forest Industrial Engineering, Kastamonu, Turkey

Keywords

allen screw
particleboard screw
adhesive
plywood
particleboard
MDF

Abstract

Screws are the leading fasteners used in furniture production today. Particleboard screws and allen screws are the most common types of screws. The resistance of the furniture connection point is one of the most important factors that determine the strength of the products produced. The use of adhesive during screwing is one of the methods applied in order to increase the resistance of the connection point. In this study, the effect of allen screw and particleboard screw on the screw direct withdrawal resistance (SDWR) of plywood, particleboard and MDF using PVAc and PU adhesive was investigated. Allen screws with dimensions of 6.3x50 mm and particleboard screws with dimensions of 6.0x50 mm were used. 1 drop of PVAc or PU adhesive was applied with a 5 ml injector into the pilot holes drilled on the samples. SDWR tests were carried out on the Zwick Roell Z050 universal testing machine according to TS EN 320 and TS EN 13446 standards. According to the results of the study, the highest SDWR was found in plywood using PU and particleboard screws. The lowest SDWR was determined in particleboard, which did not use any adhesive and allen screw was used.

✉Emre Birinci, Department of Forestry Industrial Engineering, Faculty of Forestry, Kastamonu University, Kastamonu, Turkey, e-mail: ebirinci@kastamonu.edu.tr

Introduction

Screws are used in all areas such as furniture, construction, etc. where wood and wood-based materials are used. Screws are the leading fasteners used in furniture production today. Particleboard screws and allen screws are the most common types of screws. Allen screws are undoubtedly one of the most used fasteners in the production of demounted furniture today (Efe and İmirzi, 2007).

The resistance of the furniture connection point is one of the most important factors that determine the strength of the products produced. Determining the screw direct withdrawal resistance between various types of screws used in joining building and furniture elements and wood-based materials is important in terms of the

strength of the entire systems to be created with these materials. The use of adhesive during screwing is one of the methods applied in order to increase the resistance of the connection point (Efe et al., 2009; Jivkov et al., 2017; Krzyżaniak et al., 2021).

In this study, the effect of allen screw and particleboard screw on the screw direct withdrawal resistance (SDWR) of plywood, particleboard (PB) and MDF using polyvinyl acetate (PVAc) and polyurethane (PU) adhesives were investigated.

Methods and materials

Materials

The materials used in this study were 18 mm thick marine plywood, MDF, and PB. The plywood was produced by a local company using beech veneers and phenol formaldehyde adhesive. MDF and PB boards (uncoated) are produced in a factory in Kastamonu, Turkey.

Within the scope of the study, two types of screws, zinc-coated allen and particleboard screws, and two types of adhesives, PVAc and PU (Apel Company), were used. Allen screws were 6.3 × 50 mm, and particleboard screws were 6.0 × 50 mm.

Methods

The air-dry densities of the boards were determined (TS EN 323). The boards are cut to 50 × 50 mm^2 dimensions (TS EN 13446). Pilot holes with a diameter of 80% of the screw diameter were drilled on the edges of the boards (Fig. 1). Pilot holes were drilled with a dremel drill to a depth of 80% of the length at which the screws will penetrate the sample (34 mm).

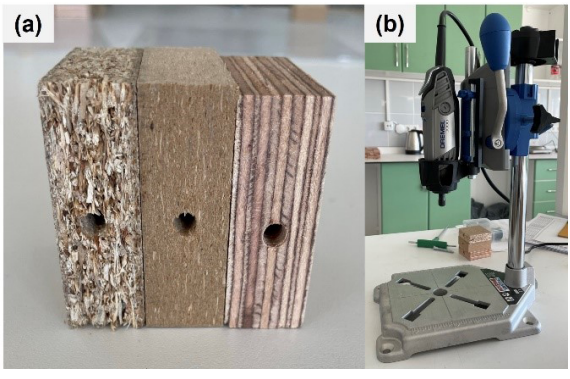

Fig. 1. (a) Plywood, MDF and PB boards; (b) Dremel drill

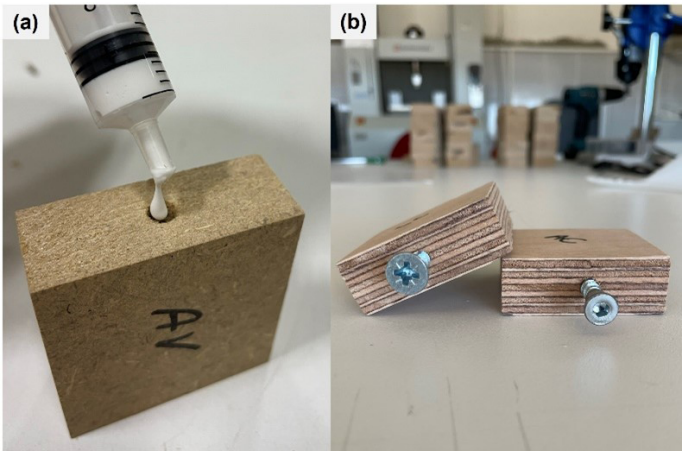

Fig. 2. a) Adhesive applying; b) Screwed boards

Within the scope of the study, 12 groups were formed based on screw type, adhesive type, and board type.15 samples were prepared for each group of boards. With a 5 ml injector, 2 drops of PVAc or PU adhesive were injected into the pilot holes drilled in the samples (Fig. 2a). Screwing processes were performed on samples with and without adhesive applied inside the pilot holes (Fig. 2b). For two weeks, plywood, MDF, and PB panels were kept at 20°C 2°C and 65% relative humidity (TS EN 320). SDWR tests were carried out on the Zwick Roell Z050 universal testing machine (TS EN 320 and TS EN 13446).

Results and discussion

According to the results of the tests carried out, the air-dry densities of the boards are shown in Table 1. According to the results in Table 1, the highest density was obtained in plywood, followed by MDF and PB, respectively. It has been understood that the results obtained are compatible with the literature.

Table 1. Air dry density test results

Board Type	Air Dry Densities (g/cm^3)
Plywood (Beech/PF)	0.75 ±0.09
MDF	0.66 ±0.04
Particleboard	0.59 ±0.06

Table 2 shows the SDWR test results applied to plywood, MDF, and PBs. When Table 2 is examined, it is clear that plywood has the highest SDWR value based on the board type.Plywood was followed by MDF and PB, respectively.

On the other hand, it is widely assumed in Table 2 that the mean SDWR of MDF is greater than that of PB.This is thought to be due to the fact that MDF has a more uniform vertical density profile than PB, its internal bond resistance, fiber/chip properties, and its adhesive type and ratio (Mcnatt, 1986; Wang et al., 2007).

Table 2. Screw direct withdrawal resistance test results

Screw Type	Adhesive type	SDWR (N)		
		plywood	MDF	particleboard
Allen screw	no adhesive	5,850.82 ±266.13	845.98 ±99.00	565.21 ±87.82
	PVAc	6,118.56 ±272.21	933.36 ±108.34	643.47 ±73.39
	PU	6,763.91 ±200.10	1,103.53 ±118.01	694.05 ±99.43
Particle-board screw	no adhesive	6,127.70 ±260.28	1,058.25 ±159.97	757.72 ±104.94
	PVAc	6,620.45 ±260.33	1,255.27 ±143.53	809.10 ±93.81
	PU	6,935.83 ±217.90	1,410.79 ±198.83	876.49 ±117.93

It has been determined that the SDWR values of all board types using particleboard screws are generally higher than those using allen screw. This study also looked at what happened to SDWR when adhesive was put in the pilot holes. It has been determined that applying the adhesive into the pilot holes generally increases the SDWR value between 6–30%. As a result of the SDWR tests carried out, the highest value was obtained in the samples applied with PU adhesive.

When the results in Table 2 were examined, it was understood that there was no linear relationship between the use of adhesive and the type of screw. PVAc adhesive was found to improve the SDWR value by an average of 6% in plywoods, 14% in MDFs, and 10% in PBs.On the other hand, it was determined that PU adhesive increased the SDWR value by an average of 14% in plywood, 30% in MDF, and 19% in PB. The use of both types of adhesive was understood to increase the SDWR value in MDF boards more than other board types.It is thought that the main reason for this is that MDF boards are more homogeneous than other boards.

Another research topic is how the use of allen screws and particleboard screws affects the SDWR value.In this study, it was found that the SDWR test results of the samples with particleboard screws were about 21% higher than the SDWR test results of the samples with allen screws.

Conclusions

The use of wood-based materials such as plywood, MDF, and PB has increased in recent years. Taking into account the mechanical properties of these materials, this study looked at how the SDWR performed depending on the type of screw, the type of adhesive used in the pilot holes, and the type of wood-based board.

According to the results of the study, it was understood that the applying of adhesive to the drilled pilot holes increased the SDWR. It has been determined that the SDWR values of the PU applied boards are higher than the PVAc applied boards.

References

Efe, H., İmirzi, H.Ö. (2007). Mechanical behaviour properties of various fasteners used in furniture production. Journal of Polytechnic, 10(1), 93–103.

Efe, H., Kasal, A., Dizel, T., Arslan, A.R., Erdem, H.E. (2009). Masif ve lamine ağaç malzemelerin (LAM) alyan vida tutma mukavemeti. Kastamonu University Journal of Forestry Faculty, 9(2), 95–105. https://app.trdizin.gov.tr//makale/T1RjeE9ERXg

Jivkov, V., Kyuchukov, B., Simeonova, R., Marinova, A. (2017). Withdrawal capacity of screws and confirmat into different wood-based panels. In: Proceedings of the XXVIIIth International Conference Research for Furniture Industry, Poznan, Poland (pp. 21–22).

Krzyżaniak, Ł., Kuşkun, T., Kasal, A., Smardzewski, J. (2021). Analysis of the internal mounting forces and strength of newly designed fastener to joints wood and wood-based panels. Materials, 14(23), 7119. https://doi.org/10.3390/ma14237119

Mcnatt, J.D. (1986). Screw-holding, internal bond, and related properties of composite board products for furniture and cabinet manufacture: A survey of literature. In: FPS proceedings 47357. Greensboro, North Carolina, USA. 47357: 30–35.

Wang, X.A., Salenikovich, A., Mohammad, M. (2007). Localized density effects on fastener holding capacities in wood-based panels. Forest Products Journal, 57(1/2), 103–109. https://www.researchgate.net/publication/237639918_Localized_density_effects_on_fastener_holding_capacities_in_wood-based_panels