JOURNAL of GREEN TECHNOLOGY and ENVIRONMENT

Research Article

Investigation of the Effect of Some Parameters on Screw Holding Resistance of OSB Used in Buildings

Hüseyin Yörür*

Karabük University, Faculty of Forestry, Department of Forest Engineering, 78100, Karabük/Turkey
* Correspondence: huseyinyorur@karabuk.edu.tr

Abstract: In this study, research has been carried out on how to provide a better screw holding resistance against the factors that the oriented strand board (OSB) used in structural areas is exposed to in the joint region. In the research, the effects of screw diameter, glue type, pilot hole diameter, screwing direction and exposure to water on the screw holding resistance of 18 mm thick OSBs were investigated. According to the experimental results, it was determined that injecting glue into the pilot hole significantly increased the screw holding resistance of OSBs. In addition, when the screwing direction parameter is evaluated, the screw holding resistance test results performed on the face of the OSB boards were higher than those performed from the edge. When the screw diameter variable was examined, it was determined that the screw diameter was directly proportional to the screw holding resistance.

Keywords: OSB; screw holding resistance; pilot hole; screw diameter; glue

Bazı Parametrelerin Yapılarda Kullanılan OSB Levhaların Vida Tutma Direnci Üzerine Etkisinin Araştırılması

Öz: Bu çalışmada, yapısal alanlarda kullanılan yönlendirilmiş yonga levhanın (OSB) bağlantı bölgesinde maruz kaldığı etkenlere karşı daha iyi bir vida tutma direncinin nasıl sağlanabileceği üzerine araştırma yapılmıştır. Çalışma kapsamında, 18 mm kalınlığındaki OSB levhaların vida tutma direnci üzerine vida çapı, tutkal tipi, pilot delik çapı, vidalama yönü ve suya maruz kalma durumunun etkileri araştırılmıştır. Deney sonuçlarına göre, kılavuz deliğine tutkal enjekte edilmesinin OSB'lerin vida tutma direncini önemli artırdığı tespit edilmiştir. Ayrıca vidalama yönü parametresi değerlendirildiğinde OSB levhaların yüzeyinden gerçekleştirilen vida çekme direnci test sonuçları, kenarından gerçekleştirilenlere göre daha yüksek çıkmıştır. Vida çapı değişkeni incelendiğinde ise vida çapının vida tutma direnci ile doğru orantılı olduğu tespit edilmiştir.

Anahtar Kelimeler: OSB; vida tutma direnci; kılavuz deliği; vida çapı; tutkal

Citation: Yörür, H. Investigation of the Effect of Some Parameters on Screw Holding Resistance of OSB Used in Buildings. Journal of GreenTech 2023, 1(1): 6-11. https://doi.org/10.5281/zenodo.8047053.

Academic Editor: Emre Birinci

Received: 26.05.2023
Revised: 16.06.2023
Accepted: 16.06.2023
Published: 30.06.2023

1. Introduction

Oriented strand boards (OSB), whose use is increasing day by day in the world, started to become widespread industrially in the 1980s. While OSB production in Turkey was 40,000 m^3/year in 2010, it reached 75,000 m^3/year in 2015. Since the need for OSB is not fully met, 160,000 m^3/year of OSB is imported annually [1]. Four different OSB classes (OSB1, OSB2, OSB3 and OSB4) are produced according to the area where it will be used. It is widely used in areas such as wall partitions, roofing and flooring, and in the construction industry. It is also an important material used in furniture, yacht, boat, vehicle body and packaging sectors [2].

OSBs must be durable and resistant to the loads and environmental factors to which they will be exposed where they are used. The type of joint selected in the connection area is one of the factors affecting the strength of the material. The appropriate joint type to be selected is an important parameter to be considered. Different joining techniques have been applied to wood and wood-based products since time immemorial. Today, metal (screws, nails, bolts, nuts, etc.), plastic and wood fasteners are widely used in the production of wood products [3]. Fasteners affect system performance and provide mechanical strength, especially when used in structures [2], [4]. Wood-based materials are usually joined with glue and screws. Joints made with screws are an indispensable fastener in terms of providing the requested resistance [5].

The resistance of screw joints is affected by factors such as screw type and torque, pilot hole diameter, screw penetration depth and glue treatment [3], [5], [6]. Rajak and Eckelman (1993) [7] determined that pilot holes increase the screw holding resistance in the face and edge direction of MDF and particleboard. They also suggested that the ideal pilot hole diameter should be approximately equal to 80 - 85% of the diameter of the screw. However, in a different study it was reported that screw holding resistance was not affected when pilot holes were drilled between 50 - 90% in particleboard and between 40 - 70% in plywood [8]. In previous studies, it has been reported that dropping glue into the pilot holes before screwing increases the screw holding resistance. Örs et al. (1998) [5]reported that by dropping PVA glue into the pilot hole, it increased by 9 - 45% in the direction parallel to the face and by 7 - 39% in the perpendicular direction. In addition, they stated that PVAc and PU glues were injected into the pilot holes and the screw holding resistance increased [9].

OSB is generally used in places exposed to outdoor weather conditions and it exchanges moisture due to its structure. Therefore, the screw holding resistance are adversely affected. In a study, it was observed that the screw tensile resistance of a wood material containing 30% moisture content was lower than that of samples containing 12% moisture content [10]. In the literature, it has been reported that injecting glue into the pilot holes to increase screw holding strength against water gives better results [9].

OSB is widely used for interior (interior wall) partitions and exterior (roof and exterior wall) partitions of structural areas. Ensuring the integrity of a structural form is related to the performance of these materials in the connection area. In this study, the effects of the moisture content of the OSB, the screwing direction (face and edge), the diameter of the screw used, the pilot hole and the glue injection on the connection area were investigated.

2. Experimental

OSB2 type boards were obtained from Kronospan/Kastamonu. The physical properties of the board are given in Table 1. PVAc (Polyvinyl acetate) Filli Boya (1.23 g/mL density and 10000-15000 mPa.s viscosity at 25 °C) and PU (Polyurethane) Soudal PRO 40P (1.1 g/mL density and 6000 mPa.s viscosity at 20 °C) were used to inject glue into the pilot holes. For the screw holding resistance test, commonly used 3.5×45 and 4.0×45 mm (diameter and length) zinc-plated steel particleboard screws were used.

Table 1. Moisture and density values of OSB2 board

Air-Dry Moisture (%)	Air-Dry Density (kg/m³)	Maximum Density (kg/m³)	Minimum Density (kg/m³)
7.93±0.74	534±32	644	461

OSBs were prepared in dimensions of 18×50×50 mm (thickness, width and length) (TS EN 13446). The samples were classified according to the tests to be applied as pilot hole (1), non-pilot hole (2), PVAc glue injected into the pilot hole (3) and PU glue injected into the

pilot hole (4). The pilot hole was drilled through the center of the part (face and edge) with a diameter of 80% of the screw diameter (Figure 1).

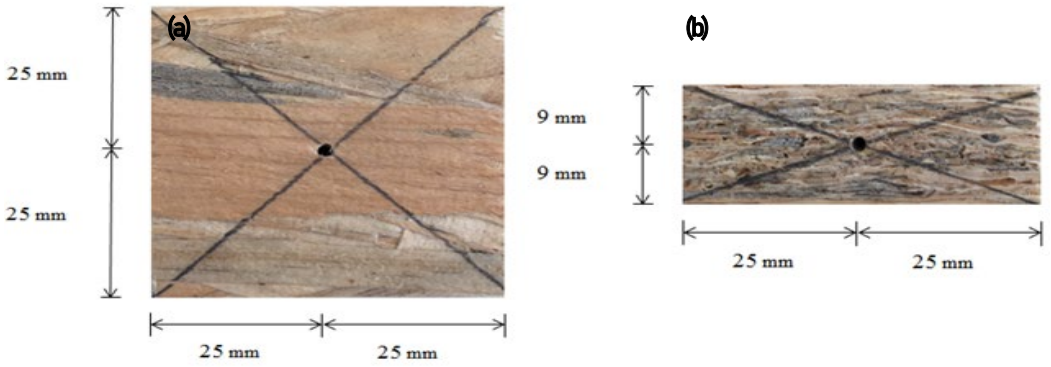

Figure 1. Pilot hole of OSB2 boards **(a)** face orientation; **(b)** edge orientation.

Glue-injected and non-glue-injected specimens were screwed 18 mm deep. The glue was injected into each sample without overflowing the pilot hole. After screwing, the samples were kept in an acclimatization cabinet at 20±2°C and 65±5% relative humidity for two weeks (EN 320). Samples to be exposed to water were soaked in water for 2 hours. Screw holding resistance tests were carried out at a speed of 15 mm/min on a Zwick Roell universal testing machine according to EN 320 and TS EN 13446 standards.

3. Results and Discussion

Table 2 shows the mean values of the screw holding resistance of OSB. The results obtained were evaluated under the following headings: effect of screw diameter, effect of screwing orientation, effect of pilot hole and glue treatment, effect of water treatment.

3.1. Effect of Screw Diameter

In this section, the effect of two different screw types with diameters of 3.5 mm and 4.0 mm on screw holding resistance was investigated. According to Table 2, it was found that the specimens screwed with 4.0 mm diameter screws generally had higher screw holding resistance than the specimens screwed with 3.5 mm diameter screws.

In the literature, different studies have been conducted to investigate the effects of screw diameter on screw holding resistance. In these studies, it was reported that those with higher screw diameter had higher screw retention resistance. It was stated that this was related to the cross-sectional area of the screw diameter [11], [12].

Table 2. Effect of screw diameter on screw holding resistance (MPa).

Water Treatment	Screwing Orientation	Pilot Hole and Glue	Screw Diameter (mm)	
			3.50	4.00
Water treated	Face	Pilot hole	$^{B}1120$	$^{A}1514$
		Non-pilot hole	$^{B}887$	$^{A}1303$
		PVAc	$^{B}1182$	$^{A}1514$
		PU	$^{A}1751$	$^{B}1521$
	Edge	Pilot hole	$^{A}1094$	$^{B}846$
		Non-pilot hole	$^{B}427$	$^{A}850$
		PVAc	$^{A}1174$	$^{B}1061$
		PU	$^{A}1647$	$^{A}1617$
Non-water treated	Face	Pilot hole	$^{A}1116$	$^{B}930$
		Non-pilot hole	$^{A}479$	$^{A}738$
		PVAc	$^{A}653$	$^{A}771$
		PU	$^{A}1128$	$^{A}1149$
	Edge	Pilot hole	$^{A}561$	$^{A}462$
		Non-pilot hole	$^{A}280$	$^{A}372$
		PVAc	$^{A}654$	$^{A}493$
		PU	$^{A}1204$	$^{A}1000$

Note: Superscript letters of A and B are homogeneous subset of post-hoc test results ($p < 0.05$).

3.2. Effect of Screwing Orientation

In this section, the effects of two different screw types with a diameter of 3.5 mm and 4.0 mm on the face and edge screw holding resistance of OSBs are investigated. It has been determined that the screw holding resistance of screws driven from the face is higher than those applied from the edge. Rajak and Eckelman (1993) [7] stated in their study that the middle layer, where the screw holding resistance of wood-based boards is the lowest and most variable, is an important factor for screw holding resistance. Therefore, they emphasized that pilot holes of suitable diameter should be drilled in order to prevent the wood-based boards from separating from the middle during screwing and to obtain maximum and less variable results. Miljkovic et al. (2007) [12] investigated the effect of chip type on the screw holding resistance results made from the edge of OSB samples. They stated that the screw holding resistance may be affected because the threads of the screw driven from the edge are in contact with small and large particles.

3.3. Effect of Pilot Hole and Glue Treatment

In this section, four different groups numbered 1, 2, 3 and 4 were examined. When Table 3 is examined, it was found that the screw holding resistance realized from the face in the samples without pilot holes was higher than that at the edge. Örs et al. (1998) [5] stated in their study that if the diameter of the pilot hole is small in hard materials, it causes strain and rupture in the direction perpendicular to the face, and cracking and deterioration in the material in the direction parallel to the face. Chen et al. (2016) [13] stated that when the diameter of the pilot hole is large, there is a decrease in the screw holding resistance due to the reduction of the contact face between the screw thread and the chips. In a study on the determination of the optimum pilot hole diameter of some wood-based materials, it was stated that drilling a pilot hole of 71% of the screw diameter from the face and 82% of the screw diameter from the edge will provide higher screw holding resistance for OSBs [14].

In Table 3, the highest screw holding strength values were obtained in PU glue injected samples. In their studies, they stated that screw holding resistance increased when glue was injected into the pilot hole [5], [9], [15]. In the literature, it has been stated that PU glue forms easy hydrogen bonding, forms an excellent bond on textile, metal, plastic, wood, glass, sand, ceramic, rubber and leather surfaces, has a high bond strength and has a high tolerance to moisture [16], [17].

Table 3. Effect of pilot hole and glue treatment on screw holding resistance (MPa).

Water Treatment	Screw Diameter	Screwing Orientation	Pilot Hole	Non-Pilot Hole	PVAc	PU
Water treatment	3.5 mm	Face	^{B}1120	^{C}887	^{B}1182	^{A}1751
	3.5 mm	Edge	^{B}1094	^{C}427	^{B}1174	^{A}1647
	4.0 mm	Face	^{A}1514	^{B}1303	^{A}1514	^{A}1521
	4.0 mm	Edge	^{B}846	^{B}850	^{B}1061	^{A}1617
Non-water treatment	3.5 mm	Face	^{A}1116	^{B}479	^{B}653	^{A}1128
	3.5 mm	Edge	^{B}561	^{C}280	^{B}654	^{A}1204
	4.0 mm	Face	^{B}930	^{B}738	^{B}771	^{B}1149
	4.0 mm	Edge	^{C}462	^{C}372	^{C}493	^{B}1000

Note: Superscript letters of A, B and C are homogeneous subset of post-hoc test results ($p < 0.05$).

3.4. Effect of Water Treatment

The results of the specimens subjected to the screw holding resistance test after being kept in water for 2 hours were statistically analyzed (Table 4). According to the results, the highest screw holding strength was determined in the PU applied samples. The screw holding resistance results of water treated samples were significantly reduced by 25-55% compared to non-water treated samples. In similar studies, it was stated that treatment with water reduces the screw holding resistance.

Table 4. Effect of water treatment on screw holding resistance (MPa).

Pilot Hole and Glue	Screwing Orientation	Screw Diameter	Water Treated	Non-water Treated
Non-pilot hole	Face	3.5 mm	$^{A}887$	$^{B}479$
		4.0 mm	$^{A}1303$	$^{B}738$
	Edge	3.5 mm	$^{A}427$	$^{A}280$
		4.0 mm	$^{A}850$	$^{B}372$
Pilot hole	Face	3.5 mm	$^{A}1120$	$^{A}1116$
		4.0 mm	$^{A}1514$	$^{B}930$
	Edge	3.5 mm	$^{A}1094$	$^{B}561$
		4.0 mm	$^{A}846$	$^{B}462$
PVAc	Face	3.5 mm	$^{A}1182$	$^{B}653$
		4.0 mm	$^{A}1514$	$^{B}771$
	Edge	3.5 mm	$^{A}1174$	$^{B}654$
		4.0 mm	$^{A}1061$	$^{B}493$
PU	Face	3.5 mm	$^{A}1751$	$^{B}1128$
		4.0 mm	$^{A}1521$	$^{B}1149$
	Edge	3.5 mm	$^{A}1647$	$^{B}1204$
		4.0 mm	$^{A}1617$	$^{B}1000$

Note: Superscript letters of A and B are homogeneous subset of post-hoc test results ($p < 0.05$).

The most important reason for this loss of resistance is the deformation of the glue, which allows the chip surfaces to stick together, against water. As a result of water treatment of OSBs, the adhesion resistance between the strands weakens and the strands begin to separate from each other. It has been stated in the studies that the type of glue and the glue ratio are important factors affecting the internal bond strength of the boards. It has been stated that the physical and mechanical properties of the board increase with the increase of the glue ratio [9], [18]–[20].

4. Conclusions

Today, the increase in the use of OSBs in structural areas, the use of the screw in the connection point of OSBs has become more important. In order to provide better screw holding resistance, it is necessary to consider some important factors such as the pilot hole, screw diameter and glue injection into the pilot holes. According to the results obtained in this study;

1. It has been determined that drilling the pilot hole in OSBs negatively affects the screw holding resistance. However, it was observed that cracks between the layers occurred in the OSBs, especially in the screwing process made from the edge in the samples whose pilot hole was not drilled. These cracks did not occur in OSBs with pilot holes.
2. It has been determined that the screw holding resistance from the face is higher than the screw holding resistance from the edge in OSBs.
3. It has been determined that injecting glue into the pilot holes of OSBs increases the screw holding resistance. Injecting glue into the pilot holes prevents micro-cracks that may occur in the OSB (despite the pilot hole) during the driving of the screw. In addition, the coating of steel screws with glue prevents oxidation and corrosion that may occur with moisture.
4. Treatment of OSBs with water significantly reduced the screw holding resistance. However, the decrease in screw holding resistance in PU glue injected samples was less than in the other groups.
5. In order for the OSBs used on the exterior of the buildings to have a good screw holding resistance, especially against wind, rain, snow and moisture, it is recommended to drill a pilot hole and inject PU glue into these holes before screwing.

Funding: This research received no external funding.

References

[1]. FAOSTAT, "Food and Agriculture Organization of the United Nation," http://www.fao.org/faostat/en/ #data/FO, Jan. 13, 2017.
[2]. M. Korkmaz, İ. Kılınç, F. Yapıcı, and M. Baydağ, "Üretim Faktörlerinin Yönlendirilmiş Yonga levhaların (OSB) Vida Tutma Direnci Değeri Üzerine Etkilerinin Araştırılması," İleri Teknoloji Bilimleri Dergisi, vol. 6, no. 3, pp. 940–948, 2017.
[3]. Ö. Tor, S. Demirel, L. Hu, and J. Zhang, "Effects of Driving Torques on Direct Screw Withdrawal Resistance in OSB," Kastamonu Üniversitesi Orman Fakültesi Dergisi, vol. 16, no. 2, Dec. 2016, doi: 10.17475/kastorman.289754.

[4]. Y. Örs, H. Efe, and A. Kasal, "Effect of Corner Wooden Wedge Geometry on Bending Strength in Demontable Leg and Table Joints of Furniture," in I. International Furniture Congress And Exhibition, 1999, pp. 457–471.
[5]. Y. Örs, R. Özen, and S. Doğanay, "Mobilya Üretiminde Kullanılan Ağaç Malzemelerin Vida Tutma Dirençleri," Turkish Journal of Agriculture and Forestry, vol. 22, no. 1, pp. 29–34, 1998.
[6]. C. A. Eckelman, "The withdrawal strength of screws from a commercially available medium density fiberboard," For Prod J, vol. 35, no. 5, pp. 21–24, 1988.
[7]. Z. Rajak and C. A. Eckelman, "Edge and Face Withdrawal Strength of Large Screws In Particleboard and Medium Density Fiberboard," Forest Product Journal, vol. 43, no. 4, pp. 25–30, 1993.
[8]. M. N. Carroll, "Relationship between driving torque and screwholding strength in particleboard and plywood," For Prod J, vol. 20, no. 3, pp. 24–29, 1970.
[9]. H. Yorur, O. Tor, M. N. Gunay, and E. Birinci, "The effects of different variables on the screw withdrawal strength of plywood," Kastamonu Üniversitesi Orman Fakültesi Dergisi, Sep. 2017, doi: 10.17475/kastorman.333858.
[10]. H. Akyıldız and A. Malkoçoğlu, "Wood screw withdrawal resistance of some important tree species growing in Eastern Blacksea region," Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi, vol. 54, no. 60, pp. 54–60, 2011.
[11]. Y. H. Chui and S. Craft, "Fastener head pull-through resistance of plywood and oriented strand board," Canadian Journal of Civil Engineering, vol. 29, no. 3, pp. 384–388, Jun. 2002, doi: 10.1139/l02-019.
[12]. J. Miljković, M. Popović, M. Điporović-Momčilović, and I. Gavrilović-Grmuša, "Edge screw withdrawal resistance in conventional particleboard and OSB: Influence of the particles type," Glasnik Šumarskog Fakulteta, vol. 95, pp. 109–117, 2007.
[13]. Y. Chen, S. Zhu, Y. Guo, S. Liu, D. Tu, and H. Fan, "Investigation on withdrawal resistance of screws in reconstituted bamboo lumber," Wood Research, vol. 61, no. 5, pp. 799–810, 2016.
[14]. J. Zhang and C. Eckelman, "Holding strength of screws in plywood and oriented strandboard," For Prod J, vol. 52, no. 6, pp. 55–62, 2002.
[15]. A. Kasal, S. Şener, Ç. M. Belgin, and H. Efe, "Bending strength of screwed corner joints with different materials," Gazi University Journal of Science, vol. 19, no. 3, pp. 155–161, 2006.
[16]. DG. Lay and P. Cranley, Polyurethane adhesives. 1994.
[17]. Pizzi A. and Mittal KL., Handbook of adhesive technology, 2nd Edition. Monticello, New York: Marcel Dekker Inc., 2003.
[18]. A. Stavroz and A. S. Leonard, "The effect of ResinContent and Face-to-Core Ratio on Some Properties of Oriented Strand Board," University of British Columbia, Faculty of Forestry, Department of Harvesting and Wood Science, vol. 43, no. 2, pp. 131–133, 1989.
[19]. Y. Göker and T. Akbulut, "Yongalevha ve Kontrplağın Özelliklerini Etkileyen Faktörler," in 1.Ulusal Orman Ürünleri Endüstri Kongresi, Trabzon, 1992, pp. 269–287.
[20]. H. Yorur, "Utilization of Waste Polyethylene and its Effects on Physical and Mechanical Properties of Oriented Strand Board," Bioresources, vol. 11, no. 1, Jan. 2016, doi: 10.15376/biores.11.1.2483-2491.