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EFFECTS OF THE PANEL AND FASTENER TYPE ON BENDING MOMENT CAPACITY OF L-TYPE JOINTS FOR FURNITURE CASES

Mehmet YUKSEL
Instructor, Mugla Sitki Kocman University in Mugla – Faculty of Technology
Address: Mugla S.K. Universitesi, Teknoloji Fakultesi, 48000 Kotekli/Mugla, Turkey
E-mail: myuksel@mu.edu.tr

Ali KASAL
Associated Professor, Mugla Sitki Kocman University in Mugla – Faculty of Technology
Address: Mugla S.K. Universitesi, Teknoloji Fakultesi, 48000 Kotekli/Mugla, Turkey
E-mail: akasal@mu.edu.tr

Yusuf Ziya ERDIL
Professor, Mugla Sitki Kocman University in Mugla – Faculty of Technology
Address: Mugla S.K. Universitesi, Teknoloji Fakultesi, 48000 Kotekli/Mugla, Turkey
E-mail: erdil@mu.edu.tr

Mehmet ACAR
Research Assistant, Mugla Sitki Kocman University in Mugla – Faculty of Technology
Address: Mugla S.K. Universitesi, Teknoloji Fakultesi, 48000 Kotekli/Mugla, Turkey
E-mail: macar@mu.edu.tr

Tolga KUŞKUN
Research Assistant, Mugla Sitki Kocman University in Mugla – Faculty of Technology
Address: Mugla S.K. Universitesi, Teknoloji Fakultesi, 48000 Kotekli/Mugla, Turkey
E-mail: tolgakuskun@mu.edu.tr

Abstract

The objective of this study was to investigate the effects of panel types and fastener types on moment capacity of L-type corner joints. For this purpose, fasteners and material types on the failure loads of L-type corner joints have been analyzed experimentally and statistically. Screw, minifix, and confirmat screw have been used as fastener types, 18mm plywood (PW), 15mm PW, 16mm partical board (PB), 18mm PB, 16mm medium density fiberboard (MDF) and 18mm MDF have been used as panel types in this study. Physical and mechanical properties of PB, PW and MDF were performed in accordance with the procedures described in ASTM D 4442 (2003) and ASTM D 1037 (2001) standards respectively. According to the results, it is concluded that PW and confirmat screw combination increase the moment capacity of the construction. Thus, both PW and confirmat screw can be recommended to use in furniture construction which need more moment capacity.

Key words*: L-Type joints; fastener; panel type; moment capacity; case type furniture.*

INTRODUCTION

Last decades, fastener materials which use without adhesives are used commonly in furniture construction because they allow to use furniture to be shipped in the knock down condition and assembled on site which significantly reduces shipping costs. This is an important consideration both in the case of domestic and export furniture.

Ready to assemble (RTA) fasteners are widely utilized for corner joints of furniture constructions. To design in MDF and PB for real size case specimens with RTA fasteners, information on moment capacity and rigidity information of the fasteners are required. In spite of their widespread use, limited information is available regarding on moment capacity of fasteners and panel types which used with RTA corner joints.

Published information is mostly related to direct withdrawal resistances of screw-type joints and moment resistances of L-type corner joints (Eckelman 1974, 1975, 1978, Zaini and Eckelman 1993).

Yerlikaya and Aktas (2012) were studied the failure loads of L-type corner joints in case-type furniture that constructed with five corner joint types which are glass-fiber composite layer (C), dowel (D), dowel + composite layer (DC), dowel + minifix (DM), and dowel + minifix + composite layer (DMC). They analyzed failure load of the joints under tension and compression moments. According to

the results, the failure load takes its highest value in the DMC case. On the other hand, it takes its lowest value in the D case.

The main problem of constructions that jointed with wood based panels is tend to split edges of the panel. This is true when butt type joints are constructed. Bachmann and Hassler (1975) were tested split of free edge of a panel was the principle source of failure with demountable fasteners which utilize metal and plastic inserts. The results of their tests provide to point out the importance of taking the natural characteristics of the material into the account when designing with PB. In particular, it is necessary to design the joints in such way that the tendency of the board to delaminate is minimized.

There were determined the effects of the screw sizes and board material type on the moment capacity and stiffness of five-sided furniture cases 18*mm* Particleboard (PB) and medium density fiberboard (MDF) were utilized for constructing the cases and nine sizes of screws were used for assembling. Results indicated that in general the five-sided cases constructed of MDF yielded significantly higher moment capacities than the PB, but the significance of MDF cases over PB cases in stiffness depends on screw diameters (Kasal *et al*. 2008).

Kasal et al. (2011), were investigated the effects of screw size on ultimate failure load and stiffness of four-sided furniture cases. Results indicated that increasing either screw diameter or length tended to to have a positive effect on the failure load and stiffness.

Simek at al. (2008) were investigated the effect of the end distance of cam lock fasteners on the bending moment resistance of knock-down corner joints. Laminated particleboard, cam fasteners and wooden dowels were used for specimen construction. L-type joint specimens 760 mm in length were tested by pressing the joint members together – also called a compression test in the angle plane. The study results showed that cam fasteners with end distance of 60 mm from the member edges perform the best.

The study by Tankut (2006) concluded that the joints constructed with medium-density fiberboard (MDF) and the trapez connector with metal parts produced the highest strength values; the rafix joints constructed with particleboard (PB) were the weakest joints evaluated. He determined that there were two readily definable types of failure, which could be categorized as follows: Type I (minifix, trapez connector with metal parts, pipe type connector, or corner fitting): The fasteners withdrew from the butt member of the corner joints along with some core material. Type II (for rafix or trapez connector with plastic parts): The fastener did not maintain its integrity under the load. The plastic part elongated from the connecting cam. A small piece was fractured from part of the fastener.

Simek et al. (2008) determined that two, three, four, or five non-glued dowels specimens had significantly higher bending moment resistance than joints that employed only two single cam fasteners but no dowels. Thus, they concluded that unglued dowels used to locate the parts for assembly substantially reinforce joints constructed with cam fasteners. Dinc (2000) concluded that the combination of plastic minifix joining elements and processed MDF was observed to give the strongest results.

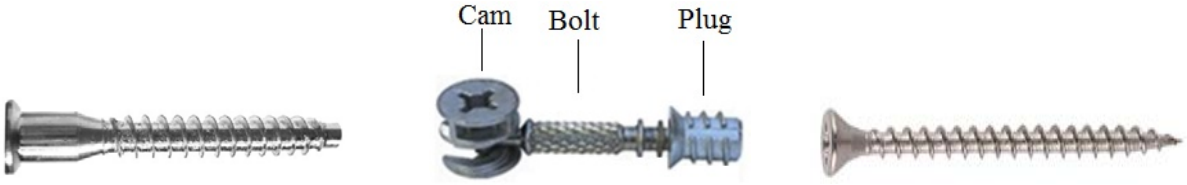
Rajak and Eckelman (1996) reported that the bending strength of corner joints was essentially directly proportional to the number of screws used, i.e., the bending strength of a two-fastener joint was twice as strong as a single fastener joint. They found that specimens failed in one of the tree modes: (1) the screw fractured, (2) the end of the edge member split, and (3) the face member fractured.

In literature, many researches were carried out to determine on moment capacity of corner joints of case type furniture. Generally, dowels and glue were used as reinforced materials in this type of joints. In this study, it was aimed to determine the best combination of panel type and fastener material without dowel and glue, which are used widely in furniture industry of Turkey, for moment capacity. For this purpose, 18mm medium densty fiberboard (MDF), 18mm particle board (PB), 18mm plywood (PW), 16mm MDF and 15mm PW were used as panel materials. Screw, minifix and Confirmat screw were used as fasteners.

METHOD, MATERIAL AND EQUIPMENT

Material

A full linear model for the two-way factorial experiments (MANOVA) was considered to investigate the effect of panel types (18*mm* PB, MDF and PW, 15mm PW and 16*mm* MDF), and connector types (screw, minifix and confirmat screw connectors which were shown in Fig. 1.



Confirmat screw Minifix Screw

Fig. 1.
Fastener Types

Experimental Design

Overall, 15 sets (5 panel types, 2 connector types) of test samples consisting of 4 replications for each, totally 60 test samples were tested for static tests. Experimental design schedule is shown in Table 1.

Table 1

Experimental design schedule

Panel Thickness	Panel type	Fastener type	Replication
18 mm	Plywood	Confirmat screw	4
		Screw	4
		Minifix	4
	MDF	Confirmat screw	4
		Screw	4
		Minifix	4
	PB	Confirmat screw	4
		Screw	4
		Minifix	4
15 mm	Plywood	Confirmat screw	4
		Screw	4
		Minifix	4
16 mm	MDF	Confirmat screw	4
		Screw	4
		Minifix	4
Total			60

Preparation and Construction of L-type Test Samples

The general test configuration of L-type test samples is shown in Fig. 2. Each test samples are consisted two structural members, a face member and a butt member. All test specimens were prepared in dimension of 300x200mm. Screw, minifix and confirmat screw were used as fasteners for joining of these members and two fasteners were used for each test samples.

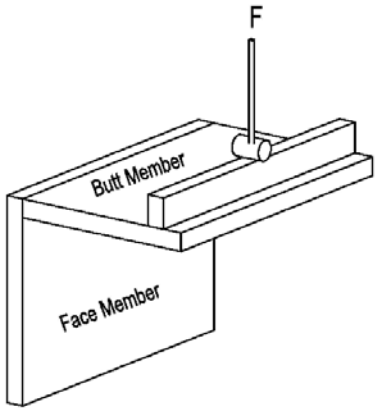


Fig. 2.
L-Type test configuration

Fig. 3 shows a typical placement of fasteners of the test samples. In order to avoid moisture content variations, the prepared test samples were conditioned in a chamber at 20ºC±2 and 65±3% relative humidity prior to tests realized.

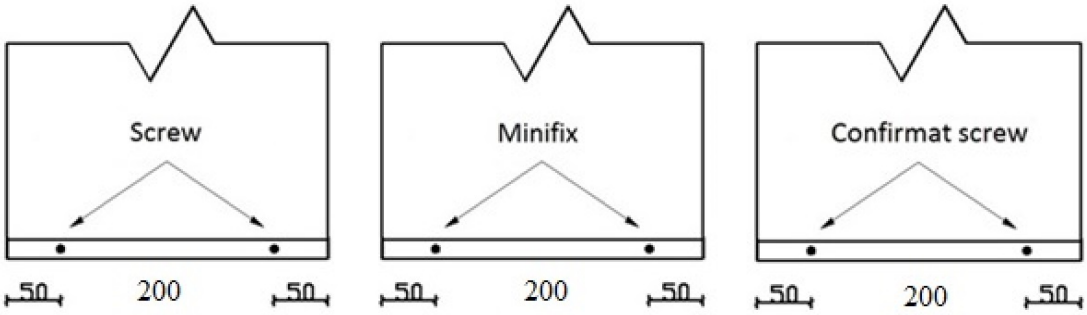


Fig. 3.
Fastener placements of test samples

METHOD

Density and moisture contents (MCs) values of test speciments were calculated according to ASTM D 4442 (ASTM 2001b) and ASTM D 1037 (ASTM 2001a) standards respectively. MCs and density of the panels are given in Table 2. All tests were carried out by a 50kN of capacity Universal testing machine with a constant loading rate 6 mm/min. Specimens were attached on the test machine by a test setup which is shown on Fig. 2. The load was applied 200mm away from the assembling point of the butt member's. The loading process was continued until the strength of the joints decreased significantly. Test measurements were realized ± 1kg sensitivity.

Table 2

Some physical properties of the panels

Panel Type	Moisture content (%)	Before drying	After drying
		Density (g/cm³)	Density (g/cm³)
18mm PW	8,44	0,56	0,56
18mm PB	7,61	0,62	0,6
18mm MDF	7,74	0,67	0,64
16 mm MDF	7,32	0,72	0,71
15 mm PW	7,8	0,54	0,53

Evaluation of the Data

Multivariate analysis of the moment capacity values of panel types and fastener types are given in Table 3. Two-factors interactions, panel types and fastener types, were analyzed statistically by ANOVA test. Results evaluated according to %5 significance level. The results showed that there were significant differences. Hence, LSD test were analyzed for each factor.

Table 3

ANOVA test result for moment capacity values

Source	DOF	Sum of Squares	Mean Square	F value	Level of sig.
Material Type (A)	4	11654.460	2913.615	141.3266	0.0000
Connector Type (B)	2	9149.675	4574.838	221.91052	0.0000
AB	8	941.348	117.669	5.7076	0.0001
Error	45	927.728	20.616		
Total	59	22673.211			

Table 4. shows homogeneous groups of moment capacity of L-type samples. Homogeneous Groups (HG) were determined according to LSD value of 6.466Nm. Moment values which shown in Table 4. were calculated according to following formula:

$$M = F_{max} * L \quad (Nm) \qquad (1)$$

where: M = Moment Capacity
F_{max} = Maximum Load
L = Moment Arm

Table 4

Homogeneous groups of moment capacities

Material Type	Connector Type	Moment (Nm)	
		X	H G
18 mm Plywood	Confirmat screw	98.10	A
18 mm Plywood	Screw	84.86	B
16 mm MDF	Confirmat screw	72.59	C
15 mm Plywood	Screw	70.14	CD
15 mm Plywood	Confirmat screw	70.14	CD
16 mm MDF	Screw	65.24	DE
18 mm MDF	Confirmat screw	60.82	EF
18 mm MDF	Screw	60.33	EF
18 mm Plywood	Minifix	55.42	FG
15 mm Plywood	Minifix	49.05	GH
18 mm PB	Screw	44.14	HI
18 mm PB	Confirmat screw	41.69	IJ
18 mm MDF	Minifix	39.24	IJ
16 mm MDF	Minifix	36.78	J
18 mm PB	Minifix	23.54	K

LSD ± 6.466 Nm; X: Average; HG: Homogeneous Group

As it can be seen in table 4, the highest moment capacity were obtained from the 18mm PW jointed with confirmat screw, while the lowest moment capacity values were obtained from 18mm PB jointed with minifix. Generally, for each thickness of panel material, PB combinations were given the weaker values than PW and MDF combinations.

Table 5 shows homogeneous groups of moment capacity of panel material types. Homogeneous Groups (HG) were determined according to LSD value of 3.733Nm.

Table 5

Homogeneous groups for moment capacities of panel material types

Material Types	Moment (Nm)	
	X	H G
18 mm Plywood	79.46	A
15 mm Plywood	63.11	B
16 mm MDF	58.20	C
18 mm MDF	53.46	D
18 mm PB	36.46	E

LSD ± 3.733 Nm X: Average HG: Homogeneous Group

Average on moment capacity values of corner joints of the samples are shown in Table 5. Test results evaluated that moment capacity of samples corner joints were significantly affected from the panel type and connector type. In general, L-type samples constructed with 18mm PW showed the highest values.

The significant difference between the 18mm PW and 15mm PW can be explained base on the thickness differences. The specimens constructed with 15mm PW showed higher values than the samples constructed with PB and MDF for all thickness levels.

The homogeneous groups of moment capacity of fastener types were shown on Table 6. Homogeneous Groups (HG) were determined according to LSD value of 2.892Nm.

Table 6

Homoneneous groups for moment capacities of fastener types

Fastener Types	Moment (Nm)	
	X	H G
Confirmat screw	68.67	A
Screw	64.94	B
Minifix	40.81	C

LSD ± 2.892 Nm X: Average HG: Homogeneous Group

According to the table, the highest moment capacity values were obtained from confirmat screw and the lowest values were obtained from minifix connectors.

RESULT AND DISCUSSIONS

In this study, the effect of panel type and fastener type on moment capacity values of L-type test samples were investigated. In this grouping data of joints, two-factors analysis of variance (ANOVA) general linear model procedure was performed. Datas were analyzed for effects of material type and fastener type interactions on the moment capacity (Table 3). The two-factor interactions, material types and fastener types, were evaluated according to LSD-value of 3.733 Nm (Table 5) and 5% significance level.

Results showed that the highest moment capacity were obtained from 18 mm PW jointed with confirmat screw while the lowest moment capacity values obtained from 18 mm PB jointed with minifix. 18mm PW panel type carried out the best value among the all other material types which used in this study. While, the highest moment capacity of fastener was obtained from confirmat screw.

Consequently, according to results of this study, it is recommended that PW, MDF and PB can be used respectively as panel type, and confirmat screw, screw and minifix can be used respectively as fastener type in order to construct furniture which is requiest higher moment capacity. Moreover, the strongest L-type joints achieved by confirmat screw and 18*mm* thickness PW combination. Thus, it is recommended that combination of 18mm thickness PW and confirmat screw can be used to make furniture constructions for obtaining higher moment capacity.

This study provides technical information, which related effects of panel type and fastener type on L-type joints, for furniture designers, product engineers and furniture manufacturers.

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