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Bending Strength of Furniture Corner Joints Constructed with Insert Fittings

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Abstract: *Bending Strength of Furniture Corner Joints Constructed with Insert Fittings.* Many different insert fittings (screws, sockets plastic - metallic, cam fittings plastic - metallic, single - double) are widely used in ready-to-assemble cabinet furniture joints to connect particleboard and MDF. In this research, the bending strength of furniture corner joints constructed with insert fittings which are offered for this kind of joints by four (4) manufacturers (Hettich Germany, Häfele Germany, Lama Slovenia and one (1) of unknown manufacturer), are studied. The insert fittings were commercially available standard items. The wood-based panels tested included particleboard and medium density fiberboard (MDF), of 16mm thickness. Research reported here indicated that bending strengths of furniture corner joints constructed with insert fittings differed slightly from manufacturer to manufacturer in particleboard and MDF, whereas, the bending strengths of the corresponding joints differed significantly from one fitting type to another. The screws with the longer cylindrical thread part without sockets, and the screws with plastic sockets of long thread part, resulted in the higher bending strength values, whereas, the lower bending strength values measured in the corner joints constructed with screws having the shorter cylindrical thread part without sockets and the screws with metal sockets.

Key words: furniture, corner joints, insert fittings, bending strength

INTRODUCTION

In cabinet furniture production, many insert fittings are used in eccentric joints to connect mainly particleboard and medium density fiberboard (MDF). Based on the literature (Eckelman 1997, 2003, Smardzewski and Prekrad 2002), it can be stated that joints are in general the weakest part of a piece of furniture, and that durability of furniture depends primarily on the quality of the joints. Consequently, the selection of the proper joint is of great importance, because it affects the design, the strength and the total quality of the furniture.

The holding strength of most of the insert fittings offered in European market have been studied by Vassiliou and Barboutis (2004, 2005). Furthermore, the stress distribution of eccentric joints constructed with screws and double plastic cam fittings (VB 36M/19) have been investigated extensively, among with trapezoid fastenings, by Smardzewski and Prekrad (2002).

This investigation was performed to provide information concerning the bending strength of corner joints constructed with insert fittings used in eccentric fastening of case furniture.

MATERIALS AND METHODS

Insert fittings which are offered by 4 manufacturers (Hettich Germany, Häfele Germany, Lama Slovenia, and 1 of unknown manufacturer) were investigated. All of the fittings were commercially available items (Figure 1).

Figure 1. The insert fittings (screws – sockets and cams) used in the investigation

The description of the fittings studied is given in the following Table 1, for screws and sockets.

Table 1. Description of the insert fittings (screws - sockets) used in the study

Code	Screw type*	Hole diameter (mm)	Hole length (mm)	Screw material	Screw diameter (mm)	Thread length (mm)		Socket use	Socket material	Socket diameter (mm)	Socket length (mm)
						Total	Cylindrical				
MANUFACTURER A											
A	**1**	5	13	Steel	5	11	11	No	-	-	-
B	**2**	5	13	Die-cast zinc	5	12	12	No	-	-	-
C	**5**	5	13	Steel	5	7,8	6.2	No	-	-	-
D	**7**	5	13	Steel	4	7,8	7.8	Yes	Brass	5	7.8
E	**6**	3	13	Steel	3	11	9	No	-	-	-
F	**6**	5	13	Steel	3	11	9	Yes	Plastic	5	13
MANUFACTURER B											
A	**1**	5	13	Steel	5	11	11	No	-	-	-
B	**6**	3	13	Steel	3	11	10.5	No	-	-	-
C	**6**	5	13	Steel	3	11	10.5	Yes	Plastic	5	12
D	**6**	3	13	Steel	3	11	9	No	-	-	-
E	**3**	5	13	Steel	5	12	8.5	No	-	-	-
F	**5**	5	13	Die-cast zinc	5	7.2	7.2	No	-	-	-
MANUFACTURER C											
A	**3**	5	13	Steel	5	12	8.5	No	-	-	-
B	**3**	5	13	Steel	5	12	9.5	No	-	-	-
MANUFACTURER D											
A	**2**	5	13	Steel	5	13	10,5	No	-	-	-

* Screw type of Figure 1.

The cam fittings selected for investigation were the single ones (Figure 1) plastic and metal, with the following dimensions for all manufacturers: diameter 20mm, height 12.5mm. Manufacturers recommendations were followed with respect to pilot hole size and the insertion of screws, screw plastic and metal sockets, and cam fittings (Figure 2).

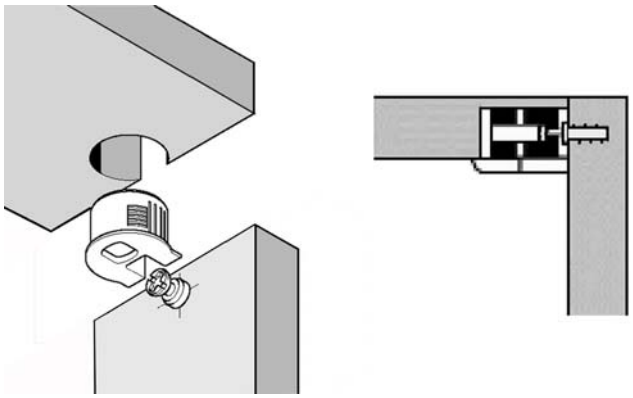

Figure 2. Application of eccentric joints investigated

Each T-shaped specimen consisted of two (2) structural members, a horizontal and a vertical member. The dimensions of the two members were: the horizontal 100mm in width, 150mm in length and 16mm in thickness, the vertical 100mm in width, 134mm in length and 16mm in thickness. The configuration of the specimens used is shown in Figure 3.

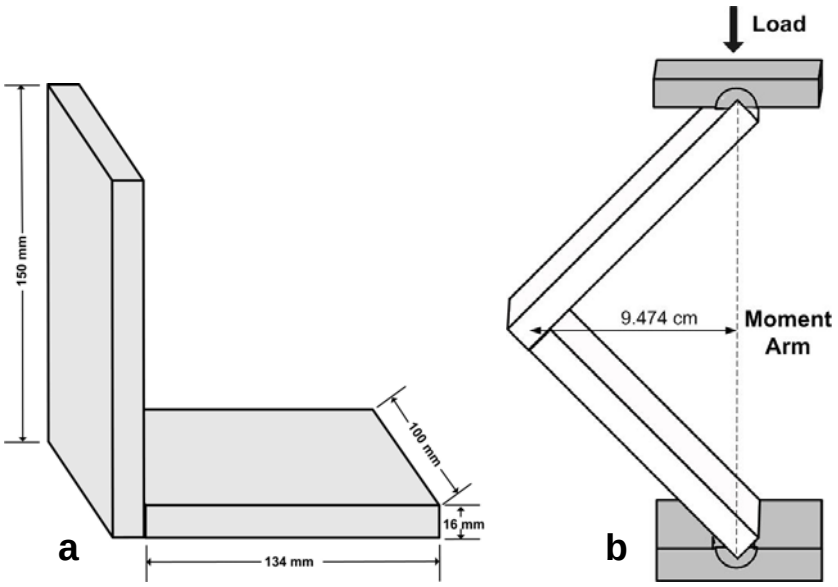

Figure 3. a) Configuration of the specimen used, and b) Method of loading the joints in compression

Specimens were constructed with particleboard (Pbd) and medium density fiberboard (MDF) of 16mm thickness. The properties of the Pbd were: density 0.634 g/cm3 and internal strength 0.58 N/mm2 and of the MDF were: density 0.680 g/cm3 and internal strength 0.59 N/mm2.

The specimens were allowed to cure for a week before testing in a conditioning room at 20^{o} C and 65% relative humidity. The method of loading the joints in compression is presented in Figure 3 (b).

DISCUSSION OF RESULTS

Values of the bending strength of the tested corner joints constructed with the selected insert fittings are presented in Table 2.

Table 2. Bending strength of insert fittings joints in particleboard and MDF

Code*	Cam fitting type	Panel type			
		Particleboard		MDF	
		Strength (N)	S.D.	Strength (N)	S.D.
Manufacturer A					
A	Plastic	66.2**	3.05	78.6	3.41
	Metal	67.6	3.98	89.8	2.74
B	Plastic	67.0	4.92	85.2	3.79
	Metal	68.0	2.83	97.6	3.98
C	Plastic	39.6	4.09	50.2	2.74
	Metal	39.0	4.55	55.2	2.86
D	Plastic	47.2	4.02	60,6	3.78
	Metal	49.6	4.88	70,4	5.15
E	Plastic	48.6	5.50	76.2	5.29
	Metal	53.0	4.92	77.8	7.57
F	Plastic	56.4	5.56	84.2	4.76
	Metal	60.0	4.99	91,4	3.89
Manufacturer B					
A	Plastic	68.0	3.26	87.0	4.03
	Metal	68,6	3.53	88.2	3.05
B	Plastic	63.8	4.66	79.4	8.74
	Metal	63.2	4.44	81,4	4.62
C	Plastic	48.8	4.82	70.8	4.34
	Metal	50.6	3,46	69.6	4.50
D	Plastic	46.8	3.43	67.6	4.60
	Metal	50.4	5.32	69.0	3.16
E	Plastic	55.8	5.20	70.0	6.53
	Metal	54.6	6.19	72.6	5.42
F	Plastic	47.8	5.92	50.4	3.10
	Metal	48.8	5.35	51.2	2.70
Manufacturer C					
A	Plastic	49.0	3.16	69.8	3.05
B	Plastic	56.2	3.58	74.8	2.70
Manufacturer D					
A	Plastic	61.4	4.53	80.4	2.46

* Code of Table 1. ** Mean values of 15 samples

Research reported here indicated that bending strength of the insert fittings differed slightly from manufacturer to manufacturer, while the bending strength of the insert fittings differed greatly from one fitting type to another.

The higher bending strength values were measured in the screws with the longer cylindrical thread part without sockets, and the screws with plastic sockets of long thread

part. The lower bending strength values gave the screws with the shorter cylindrical thread part without sockets, and the screws with metal sockets, correspondingly, in both particleboard and MDF.

Also, it was found that metal cam fittings resulted in slightly higher strength values in both, Pbd (by 4.21% in mean values), and MDF (by 6.99% in mean values), in comparison with the plastic cam fittings (with the exception of 3 fittings in Pbd and 1 fitting in MDF). Furthermore, it was found that all of the fittings resulted in higher strength values when applied in MDF (by 32.58% the plastic cam fittings, and by 35.72% the metal cam fittings), in comparison with their application in Pbd.

In order to statistically evaluate the effect of panel type and cam fitting type on bending strength a multiple variable analysis was performed. The difference between the groups regarding the effect of variance sources on bending strength has been significant ($P \leq 0.05$). All of the MDF groups differed significantly from the Pbd groups for both plastic and metal cam fittings groups with the exception of the F fitting groups of the B manufacturer. Also, it was found that the strength of 3 metal cam fittings of manufacturer A (A, B and F) differed significantly from the corresponding plastic cam fittings groups.

In the case of manufacturer A, the cam fittings resulted in bending strengths that ranged from 39.0 N to 68.0 N in Pbd (Figure 4-a), and from 50.2 N to 97.6 N in MDF (Figure 4-b).

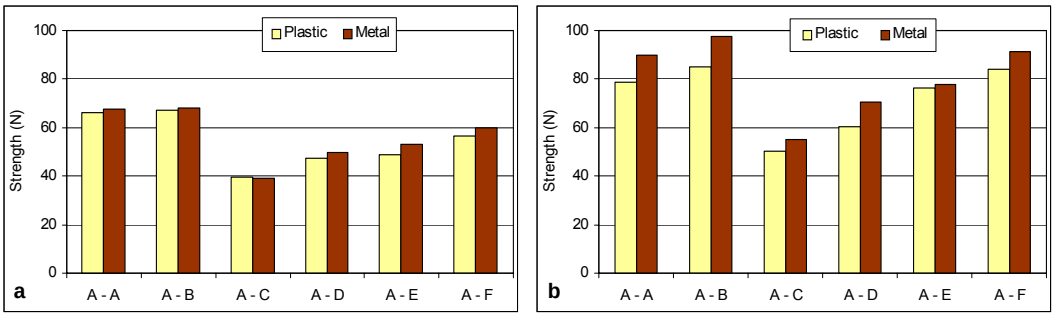

Figure 4. Bending strength of manufacturer A fittings a) in Particleboard and b) in MDF

In the case of manufacturer B, the cam fittings resulted in bending strengths that ranged from 46.8 N to 68.6 N in Pbd (Figure 5-a), and from 50.4 N to 88.2 N in MDF (Figure 5-b).

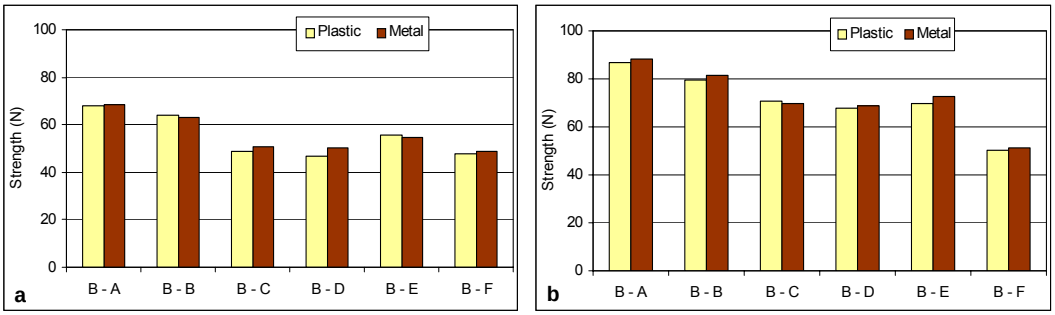

Figure 5. Bending strength of manufacturer B fittings a) in Particleboard and b) in MDF

Finally, in Figure 6-a and 6-b the strength values of the plastic cam fittings of manufacturers C and D are presented.

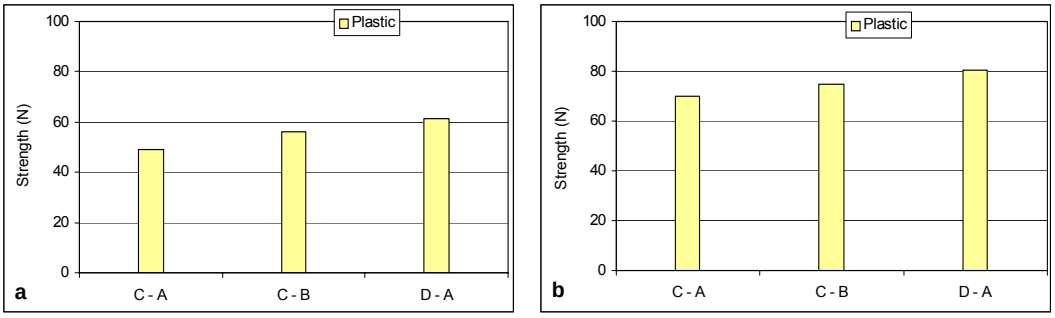

Figure 6. Bending strength of manufacturers C and D fittings a) in Particleboard and b) in MDF

CONCLUSIONS

The results of this investigation indicated that the bending strength values of the insert fittings tested differ slightly from manufacturer to manufacturer in Pbd and MDF. In contrast, the strength values differed greatly from one fitting type to another.

Also, results indicated that all of the fittings resulted in higher strength values when applied in MDF, compared to Pbd, and some metal cam fittings resulted in significantly higher strength values, in comparison to the plastic cam fittings.

Furthermore, it was found that the higher bending strength values were measured in the screws with the longer cylindrical thread part. This implies that cabinet furniture makers should be careful when choosing insert fittings.

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Streszczenie: *Wytrzymałość na zginanie połączeń kątowych ściennych wykonanych przy użyciu złączy mimośrodowych.* W pracy badano wytrymałość na zginanie połączeń meblowych wykonanych przy użyciu złączy mimośrodowych czterech producentów (Hettich Niemcy, Häfele Niemcy, Lama Słowenia oraz nieznany producent). Jako łączony materiał użyto płyty wiórowej i płyty MDF o grubości 16 mm. Z badań wynika, że wytrzmałość na zginanie złączy mimośrodowych zmienia nieznacznie się w zależności od producenta jak również to, że poszczególne typy złączy w sposób znaczny różnią się wytrzymałością. Trzpienie zawierające gwint o dużej długości części cylindrycznej a także trzpienie

współpracujące z mufą o dużej długości gwintu pozwalały na uzyskiwanie połącneń o wyższej wytrzymałości na zginanie.

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