

TENSION STRENGTH OF FURNITURE MIDDLE JOINTS CONSTRUCTED WITH BISCUITS

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Abstract

Furniture joints constructed with biscuits are widely used in the production of either permanent or dismountable joints, but there is very limited information available concerning the tension strength of the middle joints made with biscuits. This study was carried out to evaluate the tension strength of the furniture middle joints constructed with wooden and plastic biscuits, and to determine the effects of gluing technique and type of the composite board (particleboard, medium density fiberboard) on the middle joints fastened with biscuit connectors. The results indicated that MDF glued or unglued middle joints were stronger than the similar joints constructed with particleboard. Tension strength of the middle joints glued with polyurethane adhesive (Knapp PU+) was higher than the similar joints glued with PVAc adhesive. The results also indicated that middle joints strength comes mainly from the gluing on edge of the connected boards and not from the glued biscuits. The tension strength of the permanent joints constructed with plastic biscuits was stronger than the corresponding strength of the connected boards. Middle joints constructed with wooden biscuits glued in slot resulted in greater strength than the similar joints constructed with all the plastic biscuits tested (from 211.5% up to 317.3%). The unglued middle joints made with plastic biscuits appeared to have low tension strength (from 63.4 N the A plastic Biscuit in Pbd up to 298.4 N the B plastic biscuit in MDF), and the B plastic biscuit was quite stronger than A plastic biscuit (460.6% in Pbd and 296.9% in MDF).

Key words: furniture, middle joints, biscuit connectors, tension strength

INTRODUCTION

Although joints constructed with biscuits are widely used in furniture production, there is limited information available concerning the strength of the middle and corner joints made with biscuits. Even though, joint design is one of the most important steps in furniture design, still there is very little information known quantitatively. According to Eckelman (2003), joints are generally the weakest part of a piece of furniture and they are the primary cause of failure. Also, Eckelman (1971) stated that the strength and stiffness of joints used in furniture construction normally determine the furniture's strength and rigidity.

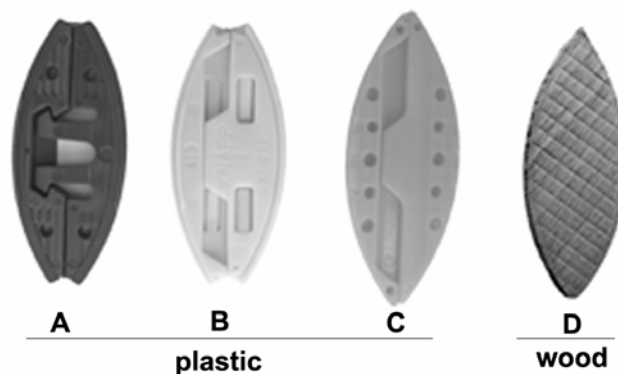


Figure 1. Plastic and wooden biscuits used in the study

Nowadays, for general woodworking there are 3 basic standard sizes of wooden biscuits (Figure 1): number 0 biscuit (15mm wide, 45mm long), number 10 biscuit (19mm wide, 53mm long), and number 20 biscuit (23mm wide, 60mm long). The thickness of all biscuits is 3.8mm. From

these 3 sizes biscuits the most common size used is number 20 (Foster, 1996). Biscuit joints, also called plate joints, are made from solid beech wood and are slightly compressed so that the plates can absorb moisture from water-based glue, causing them to swell in the slots for a tight fit and strong bond (Speas, 1994).

Apart from the wooden biscuits, there are also available some patented plastic and metallic biscuits (Figure 1), which are used either as permanent connectors by gluing or as dismountable connectors by knocking or screwing. According to the manufacturer they provide the advantages of easy to use and reduction of production costs, and no pressing is needed for their assembly (Knapp, 2005).

Tankut et al (2004) studied the effect of some factors on the compression and tension strength of furniture corner joints constructed with wooden biscuits. Georgiou (2004) studied the effect of gluing on the compression strength of the corner joints and the tension strength of the middle joints constructed with wooden biscuits.

This study was performed to provide information concerning the tension strength of the biscuits middle joints constructed with particleboard and medium density fiberboard. The objectives of this study were as follows: a) to evaluate the tension strength of the furniture middle joints constructed with different types of wooden and plastic biscuits, and b) to determine the effects on furniture middle joints connected with biscuit fasteners of the gluing technique and the type of the composite board (particleboard, medium density fiberboard).

MATERIALS AND METHODS

The configuration of biscuits used in this study is shown in Table 1. Solid beech wood biscuits were used in the study, and particularly the number 20 biscuit. From the non-wood biscuits the following three plastic biscuits manufactured by Knapp were used: a) connector FAST (referred to as A plastic), b) connector SUNNY (referred to as B plastic) and c) connector CHAMP (referred to as C plastic). According to manufacturer the connectors A plastic and B plastic are mainly used for permanent joints, whereas, the connector C plastic is used mainly for dismountable joints.

Table 1. Configuration of the biscuits used in the study

Biscuit type	Width (mm)	Length (mm)	Thickness (mm)
A plastic	25.0	56.0	4.0
B plastic	25.0	55.7	3.9
C plastic	26.0	67.0	3.8
Beech wood	24.0	60.0	3.8

The configuration of the specimens used in the study is shown in Figure 2. 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.

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. A portable biscuit joiner (Knapp) was used to make slots both on the face of the horizontal member and the edge of the vertical member. Before assembling all the slots were cleaned with compressed air to remove dust.

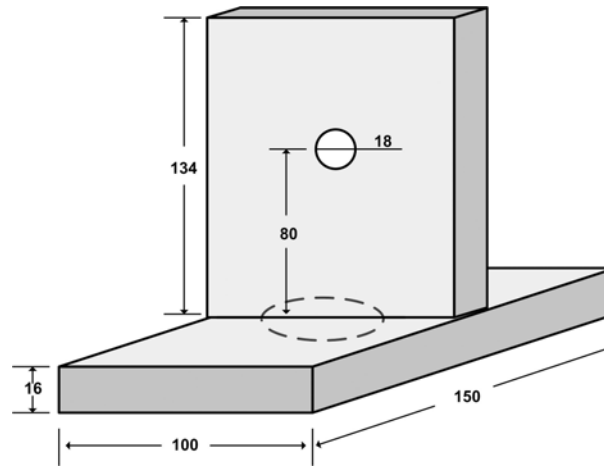


Figure 2. Configuration of the specimen used to determine middle joint strength

The specimens were assembled following the manufacturer's recommendations with either: 1) biscuits only, referred to as "unglued", 2) with glue on the biscuit and the biscuit hole, referred to as "glued in slot", and 3) with glue only on the connected edges (without glue on biscuit and the biscuit hole), referred to as "glued on edge". The glued specimens were assembled with both a polyvinyl acetate emulsion adhesive (PVAc) of the D3 durability class according to EN 204:2001 standard, and a polyurethane adhesive (Knapp PU+). The adhesive was applied to both the walls of slots and the surfaces of the biscuits. All specimens were assembled manually without any additional pressure to bring the joints together. The specimens were allowed to cure for a week before testing in a conditioning room at 20° C and 65% relative humidity. All tests were carried out on a SHIMADZU Testing Machine (Figure 3).



Figure 3. Method of testing

RESULTS AND DISCUSSION

Values of the tension strength of the tested middle joints constructed with three (3) plastic and

one (1) beech wood biscuits are presented in Table 2.

Table 2. Tension strength of biscuit middle joints

Board material and Biscuit type	Joint type				
	Unglued	Glued on edge		Glued in slot	
		PVAc	PU	PVAc	PU
Particleboard					
A plastic	63.4(5.1)*	1156.7(66.3)	1177.6(102.6)	425.4(53.8)	531.4(20.0)
B plastic	292.0(37.1)	1074.3(101.3)	1131.7(127.9)	325.8(43.5)	610.3(40.6)
C plastic				543.1(21.0)	815.5(28.6)
Beech wood				1098.7(147.2)	1271.7(52.6)
Medium Density Fiberboard					
A plastic	100.5(4.3)	1963.9(109.7)	1665.7(41.2)	426.5(51.7)	904.1(105.4)
B plastic	298.4(19.5)	1846.2(122.9)	1657.6(43.4)	374.1(43.2)	648.3(64.3)
C plastic				679.9(29.4)	830.1(43.4)
Beech wood				1033.7(144.4)	1912.5(43.2)

* Mean values (N) of 15 samples and standard deviation in parenthesis

The unglued middle joints made with plastic biscuits showed the lower values of tension strength (from 63.4 N the A plastic biscuit in Pbd up to 298.4 N the B plastic biscuit in MDF), the glued on edge middle joints the higher values of tension strength (from 1074.3 N the B plastic biscuit in Pbd up to 1963.9 N the A plastic biscuit in MDF), and the glued in slot middle joints intermediate tension strength values (from 325.8 N the B plastic biscuit in Pbd up to 904.1 N the A plastic biscuit in MDF). Apparently, the middle joints strength comes mainly from the gluing on edge of the connected boards and not from the glued biscuits. The permanent joints constructed with plastic biscuits and glued on edge appeared to be stronger in strength than the corresponding strength of the connected boards.

In most cases, it was found that tension strength of the middle joints glued with polyurethane adhesive was higher than the similar joints glued with PVAc adhesive, except of the joints glued on edge in MDF, which showed greater tension strength when PVAc adhesive was used.

Particularly, the effect of gluing technique on tension strength of the middle joints constructed with the A plastic biscuits is shown in Figure 4.

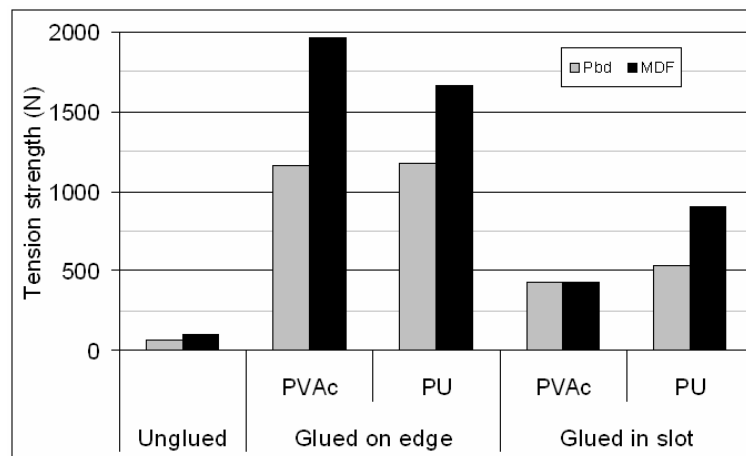


Figure 4. Effect of gluing technique on tension strength of the A plastic biscuit middle joints

We see that joints constructed with MDF were stronger than the similar joints constructed with Pbd (from 0.3% in joints glued in slot with PVAc adhesive up to 69.8% in joints glued on edge

with PVAc adhesive). On the other hand, polyurethane adhesive resulted in higher tension strength of the middle joints glued in slot (by 24.9% in Pbd and by 112.0% in MDF), whereas, the joints glued on edge were stronger when PVAc was used in MDF (by 17.9%) and slightly stronger when polyurethane adhesive was used in PBD (by 1.8%). Furthermore, the effect of gluing technique on tension strength of the middle joints constructed with the B plastic biscuits is shown in Figure 5.

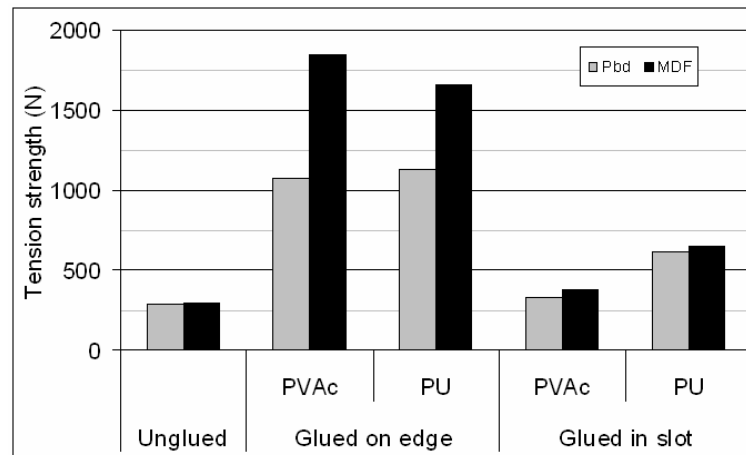


Figure 5. Effect of gluing technique on tension strength of the B plastic biscuit middle joints

We can also see that joints constructed with MDF were stronger than the similar joints constructed with Pbd (from 2.2% in unglued joints up to 71.9% in joints glued on edge with PVAc adhesive). On the other hand, polyurethane adhesive resulted in higher tension strength of the middle joints glued in slot (by 87.3% in Pbd and by 73.3% in MDF), whereas, the joints glued on edge were stronger when PVAc was used in MDF (by 11.4%) and slightly stronger when polyurethane adhesive was used in PBD (by 5.3%).

The corresponding tension strength of the middle joints glued in slot and constructed with the C plastic biscuits is shown in Figure 6.

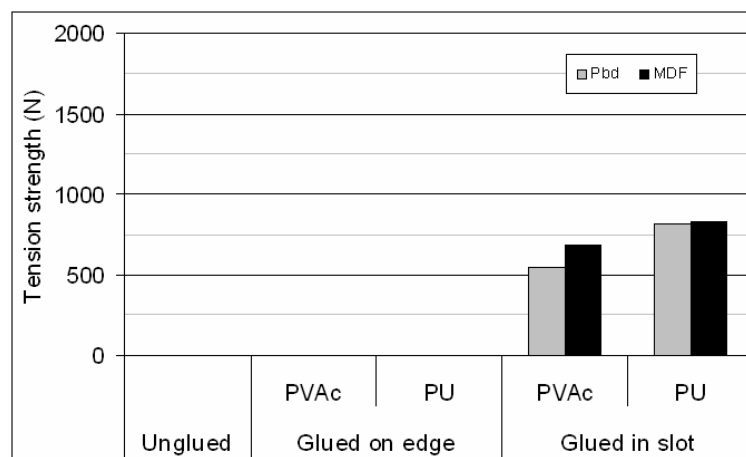


Figure 6. Effect of gluing technique on tension strength of the C plastic biscuit middle joints

We see that joints constructed with MDF were also stronger than the joints constructed with Pbd (by 25.2% in joints glued with PVAc adhesive and by 1.2% in joints glued on with polyurethane adhesive). On the other hand, polyurethane adhesive resulted in higher tension strength of the middle joints (by 50.2% in Pbd and by 22.1% in MDF).

The corresponding tension strength of the middle joints glued in slot and constructed with the beech wood biscuit is shown in Figure 7.

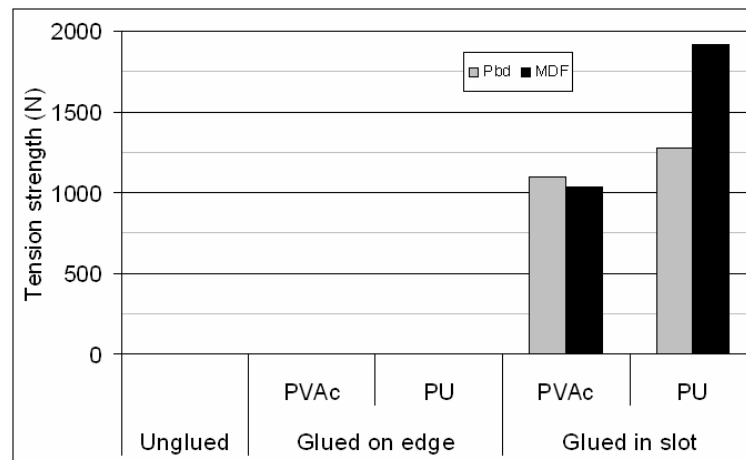


Figure 7. Effect of gluing technique on tension strength of the beech wood biscuit middle joints

We see that joints constructed with MDF were stronger than the joints constructed with Pbd when polyurethane adhesive was used (by 50.4%), whereas the joints constructed with Pbd were stronger than the joints constructed with MDF when PVAc adhesive was used (by 6.3%). On the other hand, polyurethane adhesive resulted in higher tension strength of the middle joints (by 15.7% in Pbd and by 85.0% in MDF).

Finally, in Figure 8, the effect of type of biscuit on tension strength of the middle joints glued in slot is given.

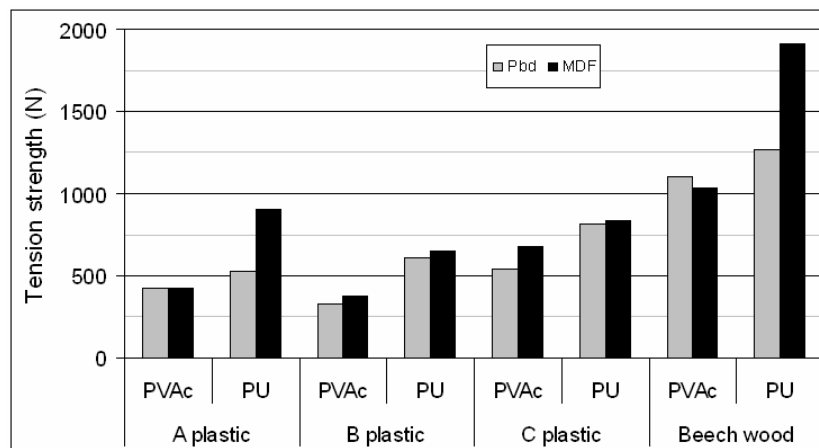


Figure 8. Effect of biscuit type on tension strength of middle joints

Middle joints constructed with beech wood biscuits resulted in greater strength than the similar joints constructed with all the plastic biscuits tested (from 55.9% compared to the joints constructed with C plastic biscuit in Pbd and glued with polyurethane adhesive up to 237.2% compared to the joints constructed with B plastic biscuit in Pbd and glued with PVAc adhesive).

CONCLUSIONS

Based on this study, the following conclusions could be drawn for the tested biscuits:

- MDF glued or unglued middle joints were stronger than the similar joints constructed with particleboard.

- Tension strength of the middle joints glued with polyurethane adhesive (Knapp PU+) was higher than the similar joints glued with PVAc adhesive.
- Middle joints strength comes mainly from the gluing on edge of the connected boards and not from the glued biscuits. The tension strength of the permanent joints constructed with plastic biscuits was stronger than the corresponding strength of the connected boards.
- Middle joints constructed with beech wood biscuits glued in slot resulted in greater strength than the similar joints constructed with all the plastic biscuits tested.
- The unglued middle joints made with plastic biscuits appeared to have low tension strength, and the B plastic biscuit was quite stronger than A plastic biscuit.

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