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COLOPHON

BENDING STRENGTH OF CORNER JOINTS CONSTRUCTED WITH BISCUITS

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Ioannis BARBOUTIS

Abstract:
Although, furniture joints constructed with biscuits are widely used in both permanent and dismountable joints, there is limited information available concerning the bending strength of corner joints made with biscuits. This study was carried out in order to evaluate the bending strength of the corner joints constructed with wood and plastic biscuits, and to determine the effects of gluing technique and type of the composite board (particleboard, medium density fiberboard) on the corner joints fastened with biscuit connectors. The results indicated that MDF glued or unglued corner joints were stronger than the similar joints constructed with particleboard. Bending strength of the joints glued with polyurethane adhesive (Knapp PU+) was higher than the similar joints glued with PVAc adhesive. The results also indicated that corner joints strength comes mainly from the gluing on edge of the connected boards and not from the glued biscuits. Corner joints constructed with wood biscuits glued in slot resulted in higher strength than the similar joints constructed with all the plastic biscuits tested (from 127.4% up to 407.7%). The unglued corner joints made with plastic biscuits appeared to have low bending strength (from 1.14 N.m the A plastic Biscuit in Pbd up to 2.32 N.m the B plastic biscuit in MDF).

Key words: furniture, corner joints, biscuit connectors, bending strength

INTRODUCTION

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

Nowadays, for general woodworking there are 3 basic standard sizes of wooden biscuits: 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).

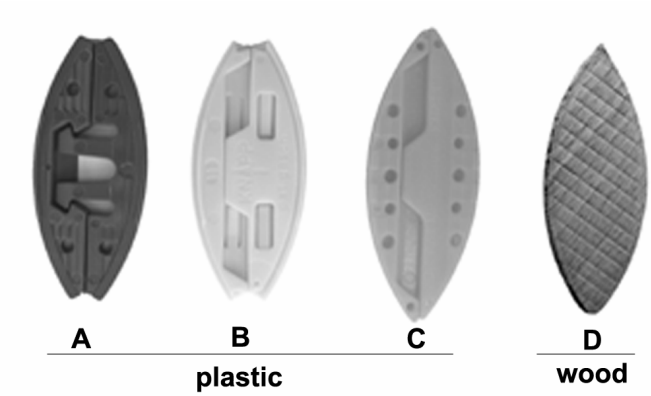

Figure 1. Plastic and wooden biscuits used in the study

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 number 20 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. Vassiliou and Barboutis (2005) studied the tension strength of furniture middle joints constructed with the same wooden and plastic biscuits and determined the effects on middle joints connected with biscuits of the gluing technique and the type of the composite board.
This study was performed to provide information concerning the bending strength of the biscuits corner joints constructed with particleboard (Pbd) and medium density fiberboard (MDF). The objectives of this study were: a) to evaluate the compression strength of the furniture corner joints constructed with different types of wooden and plastic biscuits, and b) to determine the effects of the gluing technique and the type of the composite board (Pbd, MDF) on furniture corner joints connected with biscuit fasteners.

MATERIALS AND METHODS

The general configuration of biscuits used in this study is given 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. General 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 L-shaped specimen consisted of two (2) structural members, a face and a butt member. The dimensions of the two members were: the butt 100mm in width, 150mm in length and 16mm in thickness, the face 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 butt member and the edge of the face member. Before assembling all the slots were cleaned with compressed air to remove dust.

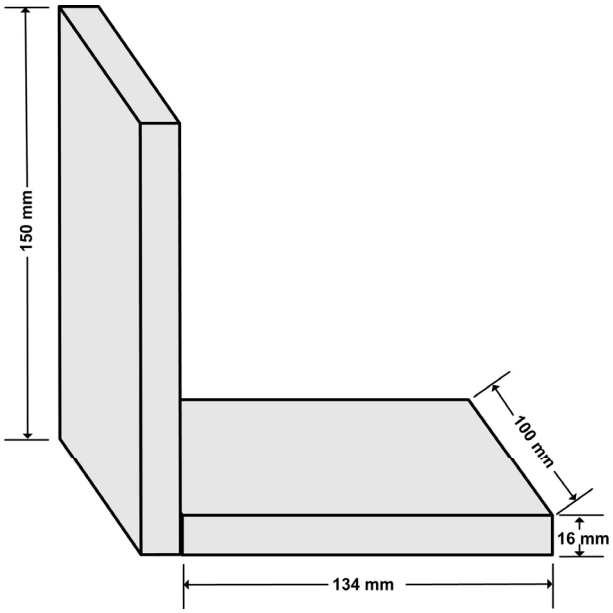

Figure 2. Configuration of the specimen used to determine corner joint strength

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^{o} C and 65% relative humidity.
All tests were carried out on a SHIMADZU testing machine (Figure 3). The strength of joints was characterized by the bending moment value at which the joint was destroyed. The ultimate bending moment was calculated by the formula: $M = F.l$ [N.m]. Where F is the magnitude of the failure forces and l is arm of bending (0.09474 m).

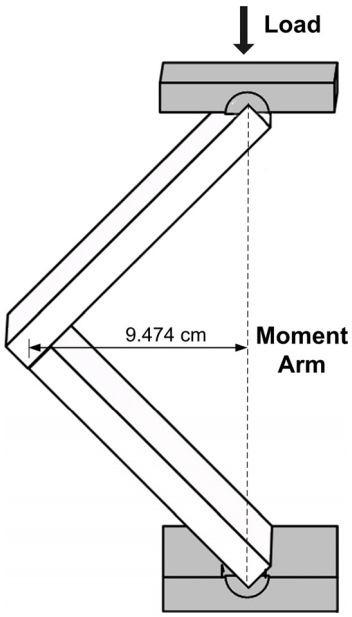

Figure 3. Method of loading the joints in compression

DISCUSSION OF RESULTS

Values of the bending strength in compression of the tested corner joints constructed with three (3) plastic and one (1) beech wood biscuits are presented in Table 2.

Table 2. Bending strength of biscuit corner joints

Board material and Biscuit type	Joint type				
	Unglued	Glued on edge		Glued in slot	
		PVAc	PU	PVAc	PU
Particleboard					
A plastic	1.14 (0.08)*	10.68 (0.14)	11.64 (0.47)	2.28 (0.19)	3.77 (0.19)
B plastic	2.17 (0.14)	10.11 (0.13)	11.58 (0.20)	1.93 (0.28)	4.48 (0.26)
C plastic				4.31 (0.28)	4.89 (0.42)
Beech wood				9.80 (0.86)	17.70 (1.40)
Medium Density Fiberboard					
A plastic	1.34 (0.09)	12.99 (0.29)	12.94 (0.22)	6.30 (0.30)	8.21 (0.17)
B plastic	2.32 (0.11)	12.13 (0.19)	12.82 (0.37)	3.53 (0.53)	5.93 (0.27)
C plastic				5.64 (0.25)	6.59 (0.28)
Beech wood				12.96 (0.70)	19.33 (0.50)

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

The results of this study demonstrate that both the type of biscuit and the gluing technique have high influence on the ultimate bending strength of the tested joints. The unglued joints made with plastic biscuits showed the lower values of compression strength (from 1.14 N.m the A plastic biscuit in Pbd up to 2.32 N.m the B plastic biscuit in MDF), the glued on edge joints the higher values (from 10.11 N.m the B plastic biscuit in Pbd up to 12.99 N.m the A plastic biscuit in Pbd), and the glued in slot joints intermediate strength values (from 1.93 N.m the B plastic biscuit in Pbd up to 8.21 N.m the A plastic biscuit in MDF). Obviously, the corner 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 strength of the joints gued with polyurethane adhesive was higher than the similar joints glued with PVAc adhesive, except of the joints glued on edge in MDF, which showed slightly greater strength when PVAc adhesive was used.
Particularly, the effect of gluing technique on bending strength of the corner joints constructed with the A plastic biscuits is shown in Figure 4.

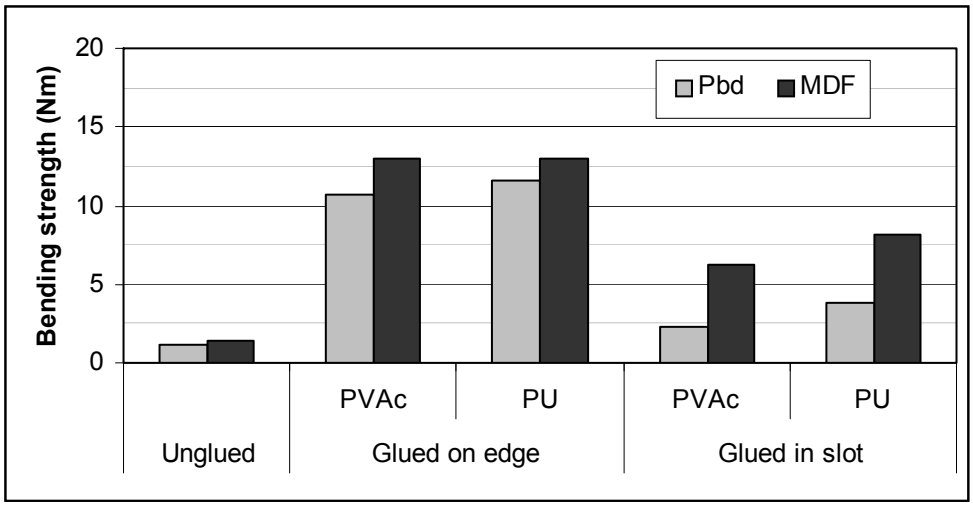

Figure 4. Effect of gluing technique on bending strength of the A plastic biscuit corner joints

We see that joints constructed with MDF were stronger than the similar joints constructed with Pbd (from 11.2% in joints glued on edge with PU adhesive up to 176.3% in joints glued in slot with PVAc adhesive). On the other hand, polyurethane adhesive resulted in higher strength of the joints glued in slot (by 65.4% in Pbd and by 30.3% in MDF), whereas, the joints glued on edge were stronger when polyurethane was used in Pbd (by 9.0%) and slightly lower in MDF (by 0.4%).
Furthermore, the effect of gluing technique on bending strength of the joints constructed with the B plastic biscuits is shown in Figure 5.

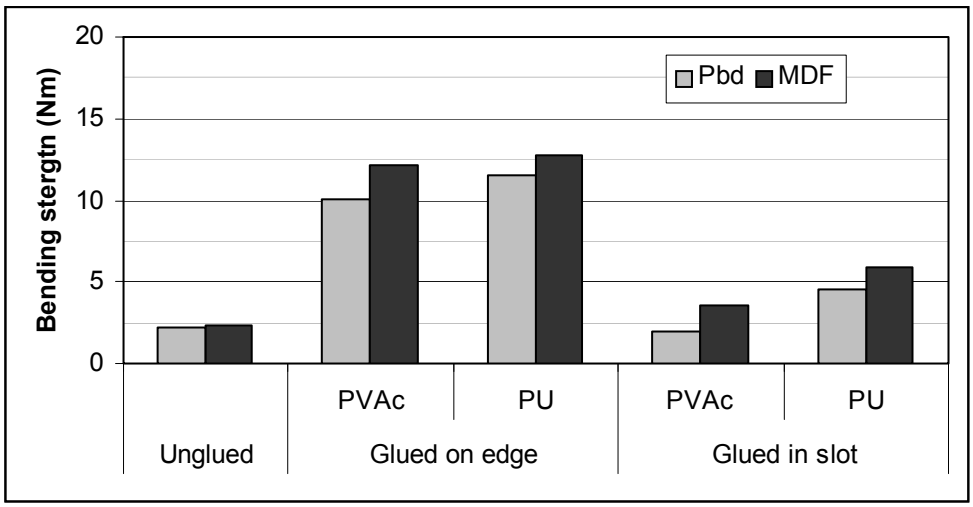

Figure 5. Effect of gluing technique on bending strength of the B plastic biscuit corner joints

We can also see that joints constructed with MDF were stronger than the similar joints made with Pbd (from 6.9% in unglued joints up to 82.9% in joints glued in slot with PVAc adhesive). On the other hand, polyurethane adhesive resulted in higher strength than PVAc adhesive in both glued on edge joints (by 14.5% in Pbd and by 5.7% in MDF) and glued in slot joints (by 132.1% in Pbd and by 68.0% in MDF).
The corresponding strength of the joints glued in slot and made with the C plastic biscuits is shown in Figure 6.

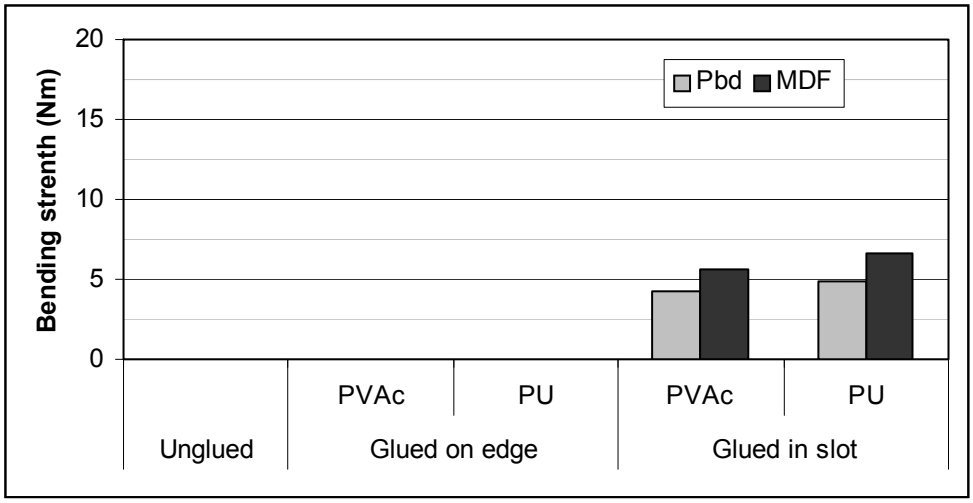

Figure 6. Effect of gluing technique on bending strength of the C plastic biscuit corner joints

We see that joints constructed with MDF were also stronger than the joints made with Pbd (by 30.9% in joints glued with PVAc adhesive and by 34.8% when polyurethane adhesive was used). On the other hand, polyurethane adhesive resulted in higher strength of the joints (by 19.3% in Pbd and by 16.8%) in MDF).
The corresponding strength of the joints glued in slot and made with the the beech wood biscuits is shown in Figure 7.

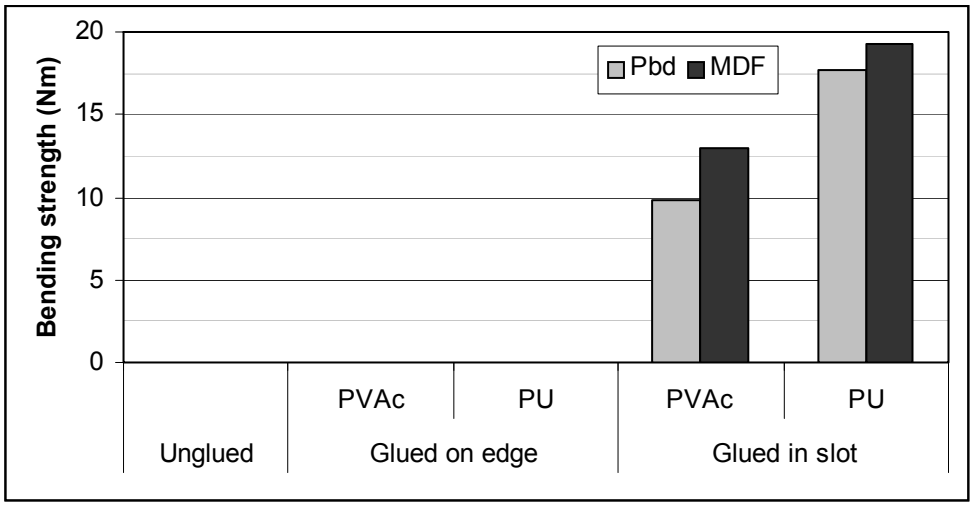

Figure 7. Effect of gluing technique on bending strength of the beech wood biscuit corner joints

We see that joints constructed with MDF were stronger than the joints made with Pbd and both adhesives (by 32.2% with PVAc and by 9.2% with polyurethane), and that polyurethane adhesive resulted in higher strength of the joints than PVAc adhesive (by 80.6% in Pbd and by 49.2% in MDF).
Finally, in Figure 8, the effect of the type of biscuit on strength of the joints glued in slot is given.

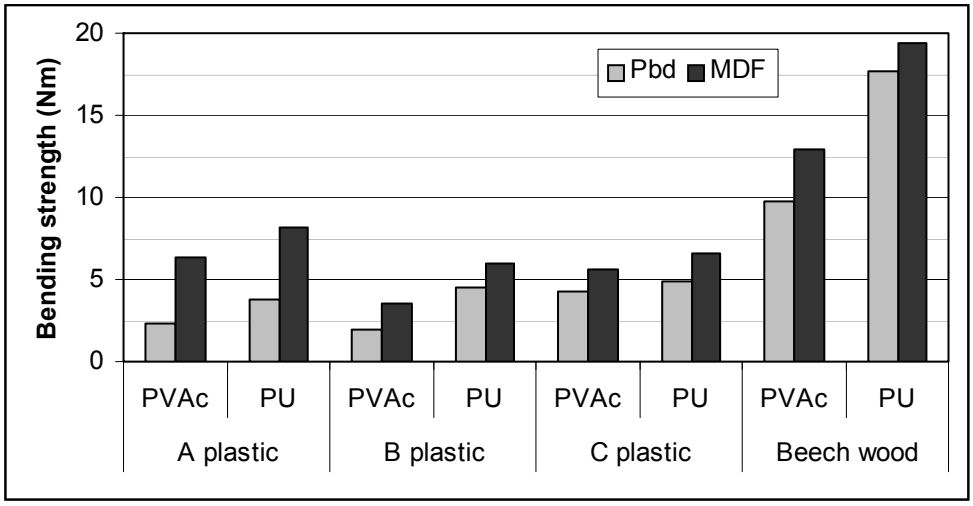

Figure 8. Effect of biscuit type on bending strength of corner joints

Corner joints made with beech wood biscuits resulted in greater strength than the similar joints constructed with all plastic biscuits in both Pbd and MDF (from 127.4% compared to the joints made with C plastic biscuit in Pbd and glued with PVAc adhesive up to 407.8% compared to the joints made 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 corner joints were stronger than the similar joints constructed with particleboard.
- Bending strength of the corner joints glued with polyurethane adhesive (Knapp PU+) was higher than the similar joints glued with PVAc adhesive.
- Corner joints strength comes mainly from the gluing on edge of the connected boards and not from the glued biscuits. The strength of the permanent joints constructed with plastic biscuits was stronger than the corresponding strength of the connected boards.
- Corner 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 joints made with plastic biscuits appeared to have much lower strength than all the glued joints, and the B plastic biscuit was quite stronger than A plastic biscuit.

REFERENCES

ECKELMAN, C.A., 1997, Bending strength of corner joints constructed with injection-molded splines, Forest Products Journal. Vol 47(4); 89-92.
ECKELMAN, C.A., 2003, Textbook of Product Engineering and Strength Design of Furniture. Purdue University Press, West Lafayette. IN.
EN 204: 2001, Classification of thermoplastic wood adhesives for non-structural applications. European Committee for Standardization, B-1050 Brussels.

FOSTER, H., 1996, Biscuit Joinery Handbook. Sterling Press. New York, USA.
GEORGIOU, A., 2004, Effect of connector, glue and panel material on strength of the furniture corner and middle joints. Master Thesis, Aristotle University of Thessaloniki, Faculty of Forestry and Natural Environment, Pp. 134 (in Greek).
KNAPP, 2005, Catalogue, Friedrich Knapp GmbH, A-3300 Amstetten, Austria.
SPEAS, E., 1994, Plate-joinery basics. Fine Woodworking, Vol. 52(11/12); 82-84.
TANKUT, A.N. and N. TANKUT, 2004, Effect of some factors on the strength of Furniture corner joints constructed with wood biscuits, Turkish Journal of Agriculture and Forestry, Vol. 28; 301-309.
VASSILIOU, V. and I. BARBOUTIS, 2005, Tension strength of furniture middle joints constructed with bisquits. 10th anniversary Conference of "Engineering Design, Interior and Furniture Design". University of Forestry. Sofia. Bulgaria.

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