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STRENGTH OF FURNITURE JOINTS CONSTRUCTED WITH BISCUITS

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Abstract: This investigation was conducted to evaluate the strength of the middle and corner joints made with wood and plastic biscuits, and to determine the effects of bonding technique and type of the composite board (particleboard, medium density fiberboard) on the joints fastened with biscuit connectors. The results indicated that MDF bonded or unbonded middle and corner joints were stronger than the similar joints made with particleboard. The strength of both middle and corner joints bonded with polyurethane adhesive (Knapp PU+) was higher than the similar joints bonded with PVAc adhesives. The results also indicated that the joint strength comes mainly from the bonding on edge of the connected boards and not from the bonded biscuits.

Keywords: furniture, corner joints, middle joints, biscuit, strength

Introduction

Nowadays, joints made with biscuits are widely used in furniture production, either as permanent or as dismountable joints. 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 joints constructed with biscuits. Joints are generally the weakest part of a piece of furniture and they are the primary cause of failure, and it is 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
Today, 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 bonding on the compression strength of the corner joints and the tension strength of the middle joints constructed with wooden biscuits. Kociszewski and Wilczynski (2001) studied the stress distribution in corner joints made with wooden biscuits, whereas Kociszewski (2005) presented the stiffness and load capacity of wooden biscuit corner joints. Vassiliou and Barboutis (2005, 2006) studied: a) the tension strength of the middle joints, and b) the bending strength of furniture corner joints constructed with the same wood and plastic biscuits and determined the effects on middle and corner joints connected with biscuits of the bonding technique and the type of the composite board.

The aim of this investigation was to present the results of relative research work performed in our laboratory, and to provide aggregate information regarding the strength of furniture joints made with biscuits, and particleboards (Pbd) and medium density fiberboard (MDF).

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

<table>
<thead>
<tr>
<th>Biscuit type</th>
<th>Width (mm)</th>
<th>Length (mm)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A plastic</td>
<td>25.0</td>
<td>56.0</td>
<td>4.0</td>
</tr>
<tr>
<td>B plastic</td>
<td>25.0</td>
<td>55.7</td>
<td>3.9</td>
</tr>
<tr>
<td>C plastic</td>
<td>26.0</td>
<td>67.0</td>
<td>3.8</td>
</tr>
<tr>
<td>Beech wood</td>
<td>24.0</td>
<td>60.0</td>
<td>3.8</td>
</tr>
</tbody>
</table>

The configuration of the specimens used in the study is shown in Figure 2. Each T-shaped specimen consisted of two structural members, a horizontal and a vertical member. Each L-shaped specimen consisted of two structural members, a butt and a face member. The dimensions of the two members were: the horizontal (butt) 100mm in width, 150mm in length and 16mm in thickness, the vertical (face) 100mm in width, 134mm in length and 16mm in thickness. Middle joints and corner joints were constructed by inserting one biscuit in order to determine their tension and compression strength respectively.

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 specimens used to determine a) corner joint strength in compression, and b) middle joint strength in tension
The specimens were assembled following the manufacturer’s recommendations with either: 1) biscuits only, referred to as "unbonded", 2) with glue on the biscuit and the biscuit hole, referred to as "bonded in slot", and 3) with glue only on the connected edges (without glue on biscuit and the biscuit hole), referred to as "bonded on edge". The bonded 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 loading a) in compression the corner joints b) in tension the middle joints](image)

**Discussion of results**

**Table 2.** Strength of biscuit joints in tension, and in compression

<table>
<thead>
<tr>
<th>Board material and Biscuit type</th>
<th>Joint type</th>
<th>Unbonded</th>
<th>PVAc</th>
<th>PU</th>
<th>Bonded on edge</th>
<th>PVAc</th>
<th>PU</th>
<th>Bonded in slot</th>
<th>PVAc</th>
<th>PU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Middle joints</td>
<td>Corner joints</td>
<td>Middle joints</td>
<td>Corner joints</td>
<td>Middle joints</td>
<td>Corner joints</td>
<td>Middle joints</td>
<td>Corner joints</td>
<td>Middle joints</td>
</tr>
<tr>
<td>A plastic</td>
<td></td>
<td>1156.7 (66.3)</td>
<td>10.68 (0.14)</td>
<td>177.6 (102.6)</td>
<td>11.64 (0.47)</td>
<td>425.4 (53.8)</td>
<td>2.28 (0.19)</td>
<td>531.4 (20.0)</td>
<td>3.77 (0.19)</td>
<td></td>
</tr>
<tr>
<td>B plastic</td>
<td></td>
<td>1074.3 (101.3)</td>
<td>10.11 (0.13)</td>
<td>131.7 (127.9)</td>
<td>11.58 (0.20)</td>
<td>325.8 (43.5)</td>
<td>1.93 (0.28)</td>
<td>610.3 (40.6)</td>
<td>4.48 (0.26)</td>
<td></td>
</tr>
<tr>
<td>C plastic</td>
<td></td>
<td>1846.2 (122.9)</td>
<td>12.13 (0.19)</td>
<td>1657.6 (43.4)</td>
<td>12.62 (0.31)</td>
<td>374.1 (43.2)</td>
<td>3.53 (0.53)</td>
<td>448.3 (64.3)</td>
<td>5.90 (0.27)</td>
<td></td>
</tr>
<tr>
<td>Beech wood</td>
<td></td>
<td>679.9 (29.4)</td>
<td>5.64 (0.25)</td>
<td>530.1 (43.4)</td>
<td>6.59 (0.28)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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The results of this study have demonstrated that both the type of biscuit and the bonding technique have caused high influence on the ultimate strength of the tested joints.

The unbonded middle joints made with plastic biscuits showed the lower values of a) tension strength (from 63.4 N the A plastic biscuit in Pbd up to 298.4 N the B plastic biscuit in MDF), and b) 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 bonded on edge joints showed the higher values of a) tension strength the middle joints (from 1074.3 N the B plastic biscuit in Pbd up to 1963.9 N the A plastic biscuit in MDF), and b) compression strength the corner joints (from 10.11 N.m the B plastic biscuit in Pbd up to 12.99 N.m the A plastic biscuit in Pbd). The bonded in slot joints showed intermediate strength values a) the middle joints in tension (from 325.8 N the B plastic biscuit in Pbd up to 904.1 N the A plastic biscuit in MDF), and b) the corner joints in compression (from 1.93 N.m in the B plastic biscuit in Pbd up to 8.21 N.m the A plastic biscuit in MDF).

Apparently, the joint strength comes mainly from the bonding on edge of the connected boards and not from the bonded biscuits. The permanent joints constructed with plastic biscuits and bonded on edge appeared to be stronger in strength than the corresponding strength of the connected boards.

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

Particularly, the effect of bonding technique on the strength of the joints made with the A plastic biscuits is shown in Figure 4.

![Figure 4](image.png)

**Figure 4.** Effect of bonding technique on a) tension strength, and on b) compression strength of the A plastic biscuit joints

Furthermore, the effect of bonding technique on the strength of the joints made with the B plastic biscuits is shown in Figure 5.
The corresponding strength of the joints bonded in slot and constructed with the C plastic biscuits is shown in Figure 6.

Figure 6. Effect of bonding technique on a) tension strength, and on b) compression strength of the C plastic biscuit joints

The corresponding strength of the joints bonded in slot and made with the beech wood biscuit is shown in Figure 7.

Figure 7. Effect of bonding technique on a) tension strength, and on b) compression strength of the beech wood biscuit joints
Finally, in Figure 8, the effect of type of biscuit on strength of the joints bonded in slot is given.

![Figure 8. Effect of biscuit type on a) tension strength, and on b) compression strength of joints](image)

Middle and corner joints made with beech wood biscuits resulted in greater strength than the similar joints constructed with all the plastic biscuits tested, in both Pbd and MDF.

**Conclusions**

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

- MDF bonded or unbonded middle and corner joints were stronger than the similar joints made with particleboard.
- The strength of the middle and the corner joints bonded with polyurethane adhesive (Knapp PU+) was higher than the similar joints bonded with PVAc adhesive.
- The joint strength comes mainly from the bonding on edge of the connected boards and not from the bonded biscuits. The strength of the permanent joints made with plastic biscuits was stronger than the corresponding strength of the connected boards.
- Both, middle and corner joints made with beech wood biscuits bonded in slot resulted in greater strength than the similar joints made with all the plastic biscuits tested.
  
  The unbonded joints made with plastic biscuits appeared to have low strength, and the B plastic biscuit was considerably stronger than A plastic biscuit, and almost equal to that bonded in slot with PVAc adhesive.

**References:**


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