ANALYSIS OF FINGER JOINTS FROM BEECH WOOD

Bettina Franke¹, Anna Schusser², Andreas Müller³

ABSTRACT: The hardwood stock in European forest increases with primary beech as the main representing species. To use the mechanical potential of hardwood it is necessary to adopt wood products known for soft wood like glulam or cross laminated timber to provide construction materials and to find new sales markets. Finger joints play a key role for the production line to respect the less available sizes of boards due to the growing and drying characteristics of hardwood. To guarantee high quality products, the production parameters like profiles of finger joints, applicable adhesives and pressing pressure and pressing time are analysed in detail using experimental test series and a numerical model.

KEYWORDS: Hardwood, Finger joints, Gluing, Strength, FEM-Analysis

1 INTRODUCTION
Nowadays there are lots of discussions in Europe about the use of hardwood as a construction material. In the Swiss forest, currently there grows more wood than been used. Especially the hardwood stock has increased since 1995. 31 % of the entire wood stock is hardwood, where the biggest part with 18 % counts for beech wood [1]. On the one hand beech wood provides excellent mechanical strength values but on the other hand the physical behaviour reduces the application possibilities due to large internal stresses associated with cracks and relative small cross sections.

Many proofed and standardised solutions and concepts are available for the quality controlled production of softwood products like glulam members or cross laminated timber. For hardwood, only few steps have been done internationally within the whole value-added-chain, like [2], [3]. However no standards for the industrial process are available and the industry avoids using hardwood as a general resource. The existing technologies for the production of structural timber should be optimized for hardwood and standards have to be created to eliminate the constraints of the application of hardwood.

For one of the key elements, the production of finger joints, comprehensive investigations were done. Finger joints are the most important joints for the production of continuous lamellas and thus for glulam. Finger joints influence also the final strength of structural timber members. The finger joint geometry, the adhesive, the amount of adhesive, the type of application, the cramping pressure and time are important factors.

The aim of the investigations is to define a finger joint manufactured from beech wood and to determine parameters for the production. The existing production steps for softwood will be proved and optimized for the application of hardwood.

2 MATERIAL AND METHODS

2.1 EXPERIMENTAL TEST PROGRAM

For the experimental test series, beech wood from Switzerland, the Jura area, was used. The average moisture content was about 10 %. The average density was about 700 kg/m³. The test program comprises finger joint lengths from 10 mm up to 50 mm and the adhesive polyurethane resin (PUR), melamine-urea-formaldehyde (MUF) and emulsion polymer isocyanate (EPI). The production was done under both laboratory and manufactory conditions. The production followed the regulations of the standard EN 385:2001. The main characteristics are summarized in Table 1.

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For each produced configuration the finger joints are tested under tension and bending according to EN 408:2011.

**Table 1: Finger joint geometry**

<table>
<thead>
<tr>
<th>Profile</th>
<th>Production</th>
<th>Finger length</th>
<th>Pitch</th>
<th>Tip width</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-10-Profile</td>
<td>Laboratory</td>
<td>10 mm</td>
<td>6.5 mm</td>
<td>0.6 mm</td>
</tr>
<tr>
<td>I-15-Profile</td>
<td>Industry</td>
<td>15 mm</td>
<td>3.8 mm</td>
<td>0.42 mm</td>
</tr>
<tr>
<td>I-15-Profile</td>
<td>Laboratory</td>
<td>15 mm</td>
<td>3.8 mm</td>
<td>0.42 mm</td>
</tr>
<tr>
<td>I-20-Profile</td>
<td>Laboratory</td>
<td>20 mm</td>
<td>6.2 mm</td>
<td>1.0 mm</td>
</tr>
<tr>
<td>I-50-Profile</td>
<td>Laboratory</td>
<td>50 mm</td>
<td>12 mm</td>
<td>3.1 mm</td>
</tr>
</tbody>
</table>

2.2 NUMERICAL MODEL

For a sensitivity analysis of the effect of the finger joint length, pitch and tip width, a Finite element model was setup as shown in Figure 1. Comprehensive parameter studies are carried out to optimize the geometry of finger joints according to the resulting stress distribution and the mechanical properties of beech wood.

3 RESULTS AND DISCUSSION

Figure 2 shows the results of the bending and tension tests series of selected finger joint profiles and adhesives used. With a finger length of 10 mm the lowest bending and tension strengths were achieved compared to the I-50-Profile with a finger joint length of 50 mm. The I-15-Profile were used under laboratory and manufactory conditions. Here, bending strength of 82 N/mm² and tension strength of 57 N/mm² could be achieved.

The results presented show a clear influence of the finger joint length on the reachable strength, like also observed for softwood. The variations of the adhesive show that a PUR-adhesive with a pre-treatment of the wood with water increases the strength. However, for the bending strength no big differences between MUF and PUR adhesive could be found.

Figure 3 shows an example of the fracture mechanism of a tension test. The specimens show different behaviour. Some show wood failure, others fail along the finger joint surface. No correlation between the failure mechanism and the strength of the finger joint observed could be found.

4 CONCLUSIONS

To produce high quality finger joints, the production process must be optimized for hardwood. First results show that different parameters are important. Further investigations are necessary. There will be experiments with different finger joint profiles and adhesives and finite element calculations of various finger joint geometries.

5 ACKNOWLEDGEMENT

The research project is proudly supported by the Federal office for the environment of Switzerland and the industry partner’s neue Holzbau AG, Purbond and Corbat Holding SA.

REFERENCES

