Proceedings of the Northern European Network for Wood Science and Engineering (WSE) 2023

Edited by Erik Larnøy
Title
Proceedings of the 19th Meeting of the Northern European Network for Wood Science and Engineering (WSE)
10-12 October 2023
Ås, Norway

Editor
Erik Larnøy

Cover design
Erik Larnøy

Published with support from SNS – The Nordic Forest Research Cooperation Committee
Preliminary experimental investigations on frame corner joints built of glulam beams, birch plywood via mechanical connectors

Yue Wang, Tianxiang Wang, Mattia Debertolis, Roberto Crocetti and Magnus Wålinder

Building Materials Division, KTH Royal Institute of Technology, Stockholm, Sweden yue4@kth.se, tiawan@kth.se, mattiad@kth.se, crocetti@kth.se, magnus.walinder@byv.kth.se

Background

Compared to steel plates, plywood plates are competitive in structural connections due to their low carbon footprint, high tolerance during assembly, relatively low cost, and less prefabrication demand (Kromoser et al. 2021). During the last few decades, plywood depicts its imprint as connections in timber structures such as truss connections, beam-to-column connections, and portal frames (Turnbull and Lefkovitch 1986; Furuheim et al. 2021; Kromoser et al. 2021). Analytical calculation models are essential for better design of birch plywood in portal frame corner joints (Wang et al. 2023a, b). However, the robustness and validity of such analytical models are yet to be examined.

Keywords: birch plywood, glued-laminated timber, frame corner joints, timber engineering.

Experimental

Two birch plywood plates were placed on the side of the glulam beams. After that, by inserting self-tapping screws VGZ9160 through, two separate glulam beams were assembled into a complete frame corner specimen, as shown in Figure 1.

Figure 1. The assembly illustration of the investigated frame corner joints.
Three test series consisting of 6.5, 9, and 21mm-thick birch plywood plates were planned, with the predicted failure modes being, respectively, failure in plywood, plywood, and glulam beams. Each test series consists of three replicates. The experimental results aim to examine the robustness and validity of analytical formulas.

After the assembly, the specimens were mounted on the test rig and loaded till failure under compression imposed on top. The loading head motion was kept at 6 mm/min to ensure the frame corner specimen failed within five to ten minutes.

**Results and Discussion**

The experimental results for test series with the plywood thickness of 6.5, 9, and 21 mm are presented in Figure 1.

![Figure 1](image)

By summarizing the experimental results, the eventual failure modes, ultimate bending moment, piston load, and rotational stiffness are presented in Table 1. The connector’s rotational stiffness $k_{rot}$ is calculated as the slope of the linear portion on the bending moment-rotational angle curve.

**Table 1.** Ultimate bending moment, failure modes and stiffness values of tested beam specimens. The number within the parenthesis indicates the standard deviation.

<table>
<thead>
<tr>
<th></th>
<th>FC_6.5mm</th>
<th>FC_9mm</th>
<th>FC_21mm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Failure modes</strong></td>
<td>Birch plywood buckling + fracture</td>
<td>Birch plywood fracture</td>
<td>Glulam fracture</td>
</tr>
<tr>
<td><strong>Ultimate bending moment (kN.m)</strong></td>
<td>33.4 (4.1)</td>
<td>51.3 (4.7)</td>
<td>72.5 (1.2)</td>
</tr>
<tr>
<td><strong>Ultimate piston load (kN)</strong></td>
<td>47.7 (5.9)</td>
<td>73.3 (6.7)</td>
<td>103.5 (1.7)</td>
</tr>
<tr>
<td><strong>Rotational stiffness (kN.m/deg)</strong></td>
<td>46.4 (3.8)</td>
<td>52.3 (1.9)</td>
<td>60.6 (1.1)</td>
</tr>
</tbody>
</table>

**Conclusions**

Proposed analytical calculation models well-predicted the ultimate load capacity and failure modes for all three test configurations. With the plywood thickness increase, both the ultimate load-bearing capacity and the stiffness increase, and this influence is more significant on ultimate loads. By increasing the plywood thickness to 21 mm with the designed screw alignment, connections that are stronger than the glulam elements were successfully achieved, which fulfills the design criterion.
References


