Influence of the moisture content on the shear strength of welded wood-to-wood connections

B. Stamm[1], Y. Weinand, B. Hahn[2], G. Rossmaier

[1]Ecole Polytechnique Fédérale de Lausanne ENAC-IBOIS
bernhard.stamm@epfl.ch

[2]Ecole Polytechnique Fédérale de Lausanne ENAC-IBOIS
benjamin.hahn@epfl.ch

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Abstract

Friction welding of wood is an innovative process, able to join pieces of wood without additional adhesives. Because of its hygroscopic properties, the wood matrix absorbs humidity at the surface from the surrounding atmosphere. Its moisture content is strongly dependent on ambient conditions and seasonal changes.
Former research showed that after samples passed a certain moisture content threshold, the creation of welded wood-to-wood connections becomes difficult and shear strength is significantly reduced.
Tests carried out on spruce samples with different moisture content should help to spot the limits of the materials moisture content, regarding the feasibility of establishing a welded wood-to-wood connection, but also to calculate which conditions lead to the most solid welded joints. If specific moisture content is needed to gain a satisfactory weld, this will have an impact on the storage conditions of the pieces to be welded.

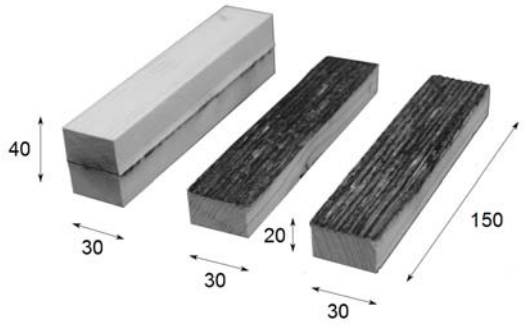

Figure 1: dimensions of the welded samples

Test series (12 samples each, dimensions according to Figure 1) with three different moisture contents (0%, 9% and 12%) were welded. Young's modulus of wood decreases with increasing moisture content and the material becomes softer. This effect leads to an increase in compression of the sample. The welding displacement, the sum of a displacement due to compression and a displacement due to decomposition, is the stop criteria for the process. It is a function of the amount of thermally modified material forming the interfacial adhesive layer. This has to be increased with increasing moisture content to reach a satisfactory weld. For the three moisture contents the welding displacement was varied in 0.25 mm steps (0%: 1 – 1.5 mm; 9%: 2.5 – 3 mm; 12%: 3 – 4 mm), in the ranges which gained the best results for each particular moisture content.
The samples were analysed with regard to the shear strength of the connection. The results indicate that moisture could have, contrary to former findings, a negative effect on the shear strength of the welded connection. Oven dried wood showed 44% better results for interfacial shear strength (5.1 MPa), when compared with moist samples (maximum value of 2.7 MPa). Standard deviation is also more even for dry samples.

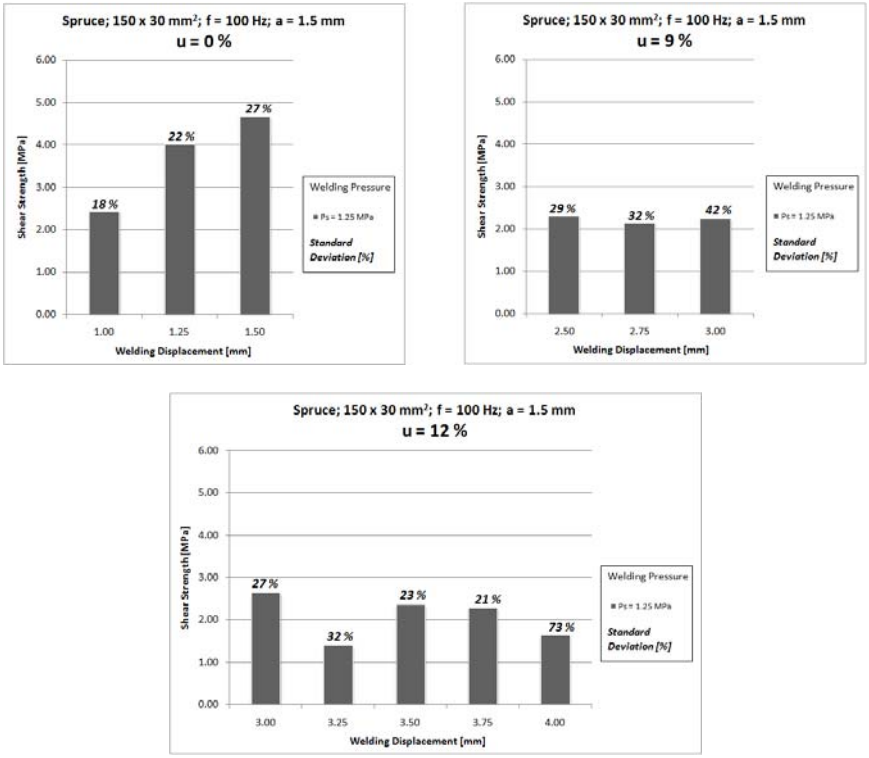

Figure 2: Shear strength of the test series (12 samples each) as a function of the moisture content

It is not yet clear, how and to what extent the presence of humidity can harm the process. During friction welding, temperatures reach values of over 400°C. At this temperature, water evaporates immediately and leaves the interface together with the smoke, or is driven into the cell structure. The high temperature is beneficial for chemical reactions between the different compounds forming the wood matrix.
Further tests should show at which threshold the water starts to influence the formation of the welded connection.
For the future application of this technology, welding of wood with low moisture content will lead to deformation by swelling during the adaptation to the actual ambiant moisture content of the location, where it is employed. The resultant stresses provoke cracks at the weld, which is quite brittle.

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