Short-report of the research project

New potentials in structural timber construction with acetylated beech

funded by

Bundesinstitut für Bau-, Stadt- und Raumforschung
im Bundesamt für Bauwesen und Raumordnung

FORSCHUNGSINITIATIVE ZukunftBAU

Project management: Technical University of Kaiserslautern
Faculty of Architecture, Department of Structure and Material
Prof. Dr.-Ing. Jürgen Graf

Official in charge: Dipl.-Ing. Reiner Klopfer, Dipl.-Ing. Dennis Röver

Introduction:

The use of beech wood for building products despite high strength of the boards finds only a limited implementation. Reasons for this is a time-consuming production process of the board, the bonding properties of beech wood and the still unresolved manufacturing process for “finger joints” of continuous boards with load capacity near of the board raw material. The minor durability of beech, high shrinkage and swelling dimensions (radial and tangential with factor 1.6 higher than spruce) and the associated moderate dimensional stability of the construction products made of beech also limit the implementation.
In case of weathering of e.g. bridges and towers native beech wood is therefore excluded. On the other hand, climate change and the associated forest conversion will increasingly provide beech wood. One approach to the use of beech wood in weathered exterior areas could therefore be modified beech that enhances durability and dimensional stability.

Subject of the research project:

Acetylated beech achieves durability class DK 1 due to the limited hygroscopicity and the removal of a large part of the hydroxyl groups from the cell structure, making it possible to replace tropical wood as a building material in outdoor use (Use class NKL 3). The modification of beech wood with acetic anhydride, no toxic substances are produced, that means recycling and disposal are easily possible. Acetylated beech wood is environmentally friendly. However, acetylation alters the bonding properties and mechanical properties of beech wood. In this research project, therefore, experimental investigations on high-quality, presorted beech for gluelam beams with> GL 48 (knot-free, dyn. E modulus> 15 000 N / mm², component width 100 mm) on small samples, subsamples and samples in component size according to DIN EN 384 and DIN EN 408 performed and derived therefrom average strengths and stiffness can be determined. The properties of acetylated beech wood should be compared with the properties of native beech wood.
The aim is to provide basics for the static calculation of constructions made of beech e.g. bridges, towers, hall structures, car parks, roofs, facades, balconies, etc. with this innovative building material.

Conclusion:

The previous test series have shown, with regard to suitable adhesives, that resorcinol-phenol-formaldehyde adhesives (reference here Auerodux 185) show the best results. For large-scale application, it would be necessary to examine whether similar properties can be achieved with other adhesives from this product group.

In order to use melamine-urea-formaldehyde adhesives and to achieve comparable properties as the resorcinol-phenol-formaldehyde adhesives, modifications of the wood or the adhesive formulations would have to be made and tested. Here the following measures could be considered:
- Plasma treatment of the wood surface before bonding (increasing the polar properties)
- Addition of surfactants to the adhesive (increase wettability)
- Pretreating the woods with a surfactant (increase wettability)

The tested boards with “vertical" veneer layers show in comparison to solid wood boards high bending strengths and a low range of these properties. Here, an increase in the characteristic strength values of 44% (79.8 N / mm² to 115 N / mm²) could be achieved. The production of acetylated glulam beams with a veneer lumber layer in the tensile zone could be a convenient way to provide high strength and durable wooden beams for the exposed exterior area.

Beech will be available in large quantities in the future and has the potential to be used increasingly in structural timber construction.
The availability as a construction product may increase significantly in the future when questions of strength grading, the use of low quality parts of wood and market provision on the one hand, as well as issues of bondability, finger jointing and durability, also for outdoor uses on the other hand be examined and solved.

The influence of spiral grain on the properties of longitudinal tension, transverse tension and shear strengths was even more problematic, and in the case of acetylated wood, the more brittle behavior in transverse tension (cracking of the board raw material with low transverse stress) was also problematic. Much of these strength-reducing properties can be compensated by homogenization effects.

Key data:

Short title:	Acetylated beech in structural timber constructions
project management:	Technical University of Kaiserslautern, Faculty of Architecture, Department of Structure and Material Prof. Dr.-Ing. Jürgen Graf
Total costs:	206.319,99 € €
Share of federal subsidy:	110.526,10 €
Project duration:	24 month

Pictures:

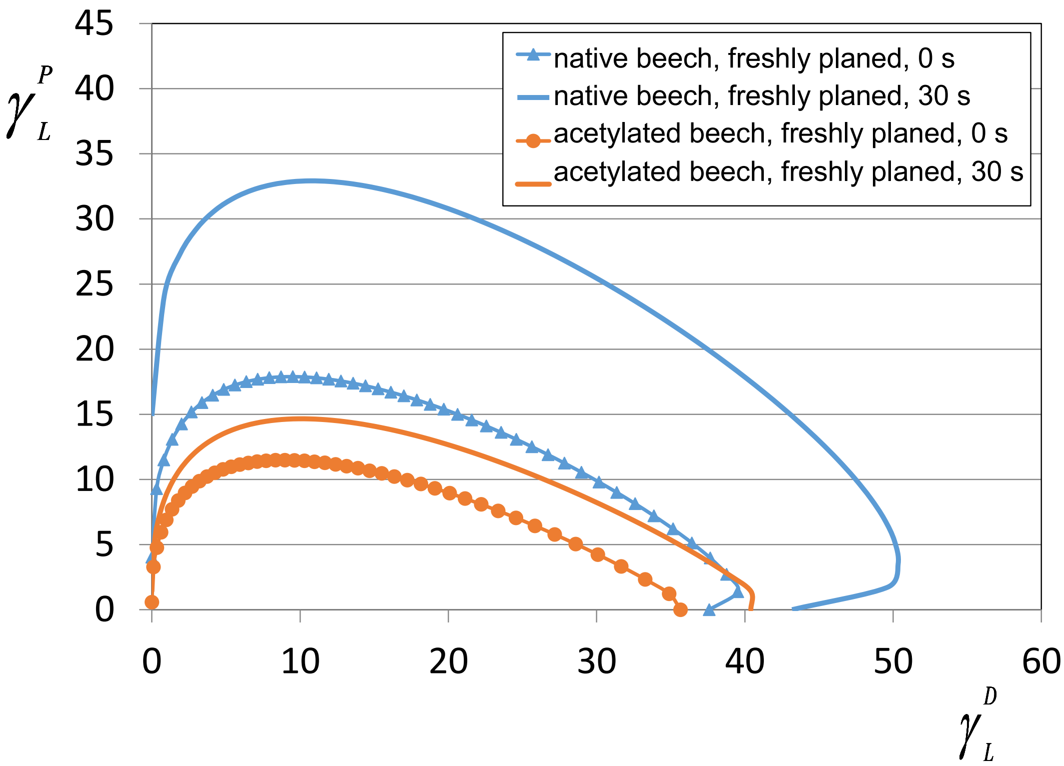

Fig.1: Wetting behavior of beech after planing, immediately after application of the test fluids and after 30 seconds. The wettability of acetylated beech (orange) is significantly lower than that of the native beech (blue).

γ_L^p = polar liquid surface energy [mJ/m²]

γ_L^d = disperse liquid surface energy [mJ/m²]

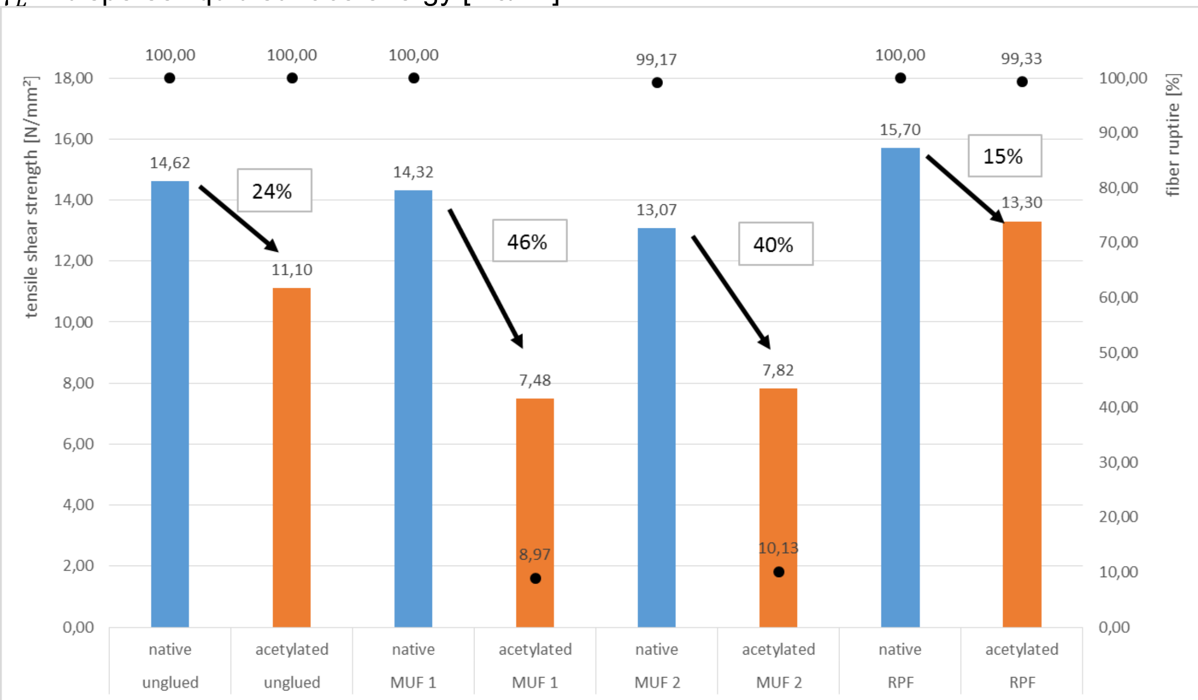

Fig. 2: Average tensile shear stresses on native and acetylated woods, unglued and with different adhesives and the associated wooden fiber rupture. The reduction native to acetylated is expressed percental, the wooden fiber ruptures are marked with black dots.

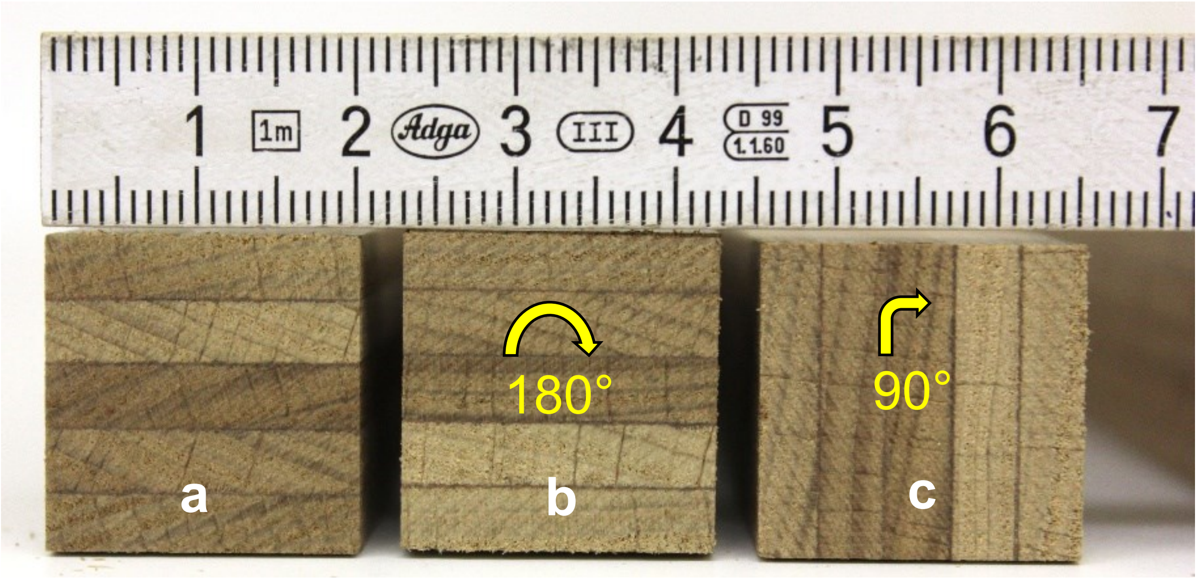

Fig. 3: For orienting tests test specimens made from 5 sawing veneers were cut out. Two specimens were rotated, one by 180°, the other by 90 ° (vertical veneer layers). In the vertical veneer layers, the test specimens all showed a shiver fracture in the 4-point bending test.

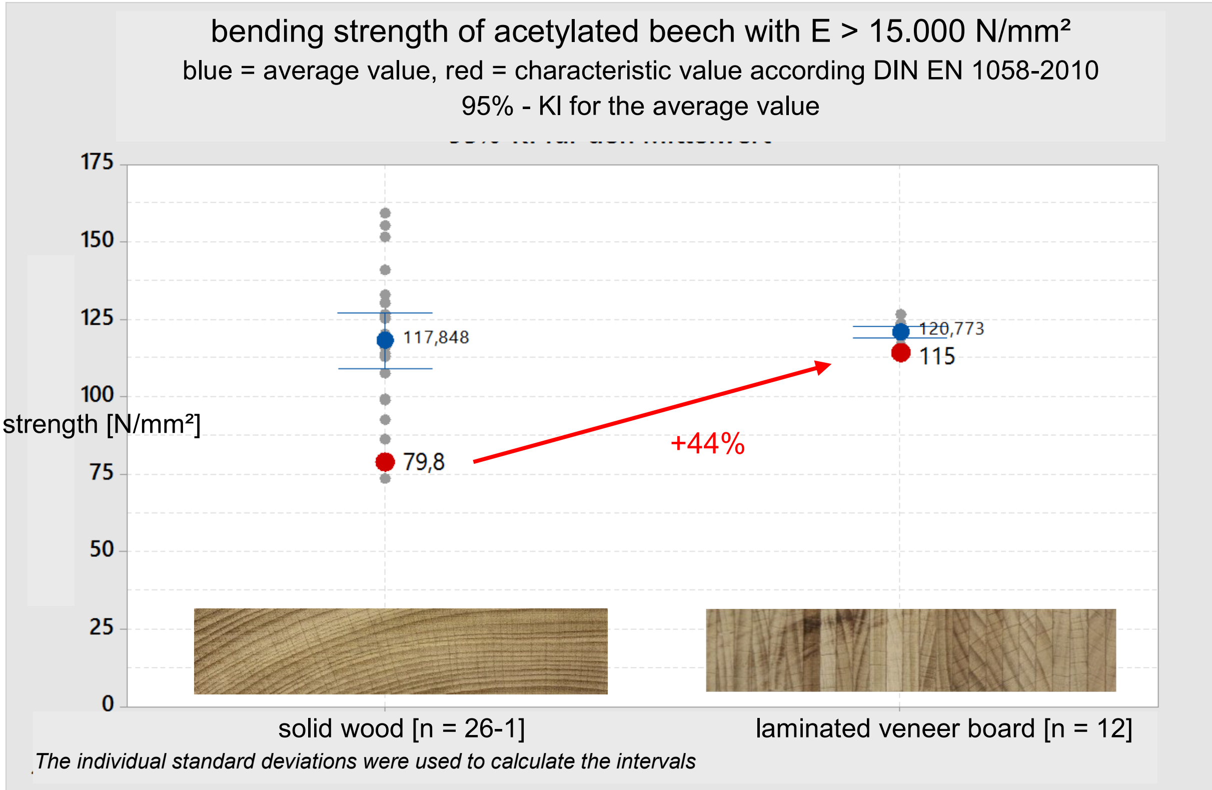

Fig. 4: Average values and characteristic values of the bending strength of the acetylated laminated veneer boards compared to acetylated solid wood. The solid wood boards have an E-modulus> 15,000 N / mm², the modulus of elasticity of the veneers is unknown.

Fig. 5: „New” glulam beam made of acetylated beech. The lower board is made of vertical veneer layers and is arranged in the tension zone of the beam.