Short-report of the research project

Potentials of using cross laminated timber production waste for manufacturing components in timber

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Introduction

Cross laminated timber (CLT) is a high performance building material for wall, ceiling and roof structures. It is dimensionally stable and reliably calculable. However, there is a lot of waste in the production of building components (wall / ceiling elements), which can vary up to 20% of the raw material. The aim of this project is to develop new possible ceiling and wall constructions, which use the waste materials.

Subject of the research project

There is a lot of waste in the production of cross laminated timber (CLT) components. In part, these are marginal sections from the plate production by trimming the board plywood boards. The wood plate manufacturers use these as squared timbers and spacers for transport. On the other hand, during the cutting of the CLT components the large-format door and window cutout often do not find any material re-use. This project will research these residual plates, which do not find any material re-use, for the cascade use of CLT. In order to make optimal use of the waste, a script will calculate the number and the necessary geometry of the individual elements for the desired ceiling and wall constructions, which use the CLT-production waste. A portal processing plant can use this script to produces the basic modules from the door and window cut outs during production. The script is constantly updated and developed in line with the progress of investigations and developments in ceiling and wall construction.

The dimensions and plate thicknesses of CLT production waste were first measured and evaluated in tabular form according to materials provided by Eugen Decker Holzindustrie AG. The most common waste are approx. 2.0 x 0.8m (door cutout) and approx. 1.26 x 0.9m (window cutout) of 106W-5 BSP plates. 106W-5 BSP plate is the five layer board structure, with three longitudinal layers (outer layers and middle layer: fiber direction to the longitudinal side of the remaining pieces, each 20 mm) and two transverse layers (23 mm each). These two most common kinds of waste will be used as the base modules of the study. The identical interlocking of the wall and ceiling elements was the basic idea for further consideration so that new wall and ceiling elements could be produced from these residues in a simple and production oriented manner.

For transmission of the shear forces, the interlocking was developed into the offsets shape along the joint edges of the CLT wasted plates. Before the experiment, FEM program ANSYS was used to conduct preliminary simulation and determine the location of the stress concentrations. Through simulation results, concrete truss model was designed for the later design.

Because of the anisotropic behavior of the wood, just consideration of the force flow in the undistorted state of timber construction is not sufficient to realistically depict the actual force transmission in the discontinuity region of the connection. Low tensile stresses perpendicular to the fiber, which cause the transverse tensile strength to be exceeded, lead to the formation of cracks in the fiber direction. The force flow in the concrete truss model must be considered, which changed because of the formation of cracks. The concrete truss models in wood construction are set up on the distorted system. The arrangement of tensioned screws at the location of the vertical tensile stress from the concrete truss model allows an increase in load. Therefore, in a further step, the concrete truss model with a transverse tensile reinforcement will be used in order to increase the load-bearing capacity of shear forces.

The experiments were conducted in the T-Lab of the Technical University of Kaiserslautern using a path-controlled two-column test frame (Marke Wekob) with F_{max} = 50 kN. The experimental speed was 2 mm/min and the measuring frequency was 50 Hz. The breaking load F_{max} and the deformations at the load application were measured. The experimental load increases in a linear manner. When the force was reduced by 25%, the experiment is stopped. Each experiment consisted of ten BSP 106W-5 samples with a width of 100mm. Electronic resistance measurement method controls wood humidity at 10%. The load-bearing capacity of the shear force connection for ceiling elements is guaranteed up to 6.50 m. The compressive forces from the bending moments of the ceiling plates were transferred via axial compressive contact of the uppermost lamination in the shear force joint. The transmission of tractive force from the force pair for bending was achieved by gluing additional board lamellas to the underside of the board.

Conclusion

The experimental results have shown that the roof made of CLT production waste will reach the best state when shear force joint and 2 x 20mm board layers as bending tension zone reinforce it. Alternatively, three-layer CLT plates can also be used as the tension zone to simplify production. Beamed ceiling with detachable connections from CLT production waste also make economic sense. With the possibilities of manufacturing in timber construction and digitalization, this recycling potential can be applied to all installed BSP plates and BSP slices and thus lead to consistent construction methods in timber construction.

Key data:

Short title:	Recycling of cross laminated timber production waste
Project management:	Technical University of Kaiserslautern Faculty of Architecture, Department of Structure and Material Prof. Dr.-Ing. Jürgen Graf University of Konstanz - Technology, business and design Faculty of Architecture, Department of Building Construction and Design Prof. Dipl.-Ing. Stefan Krötsch
Total costs:	336.552,15 €
Share of federal subsidy:	188.026,68 €
Project duration:	27 Months

Figures

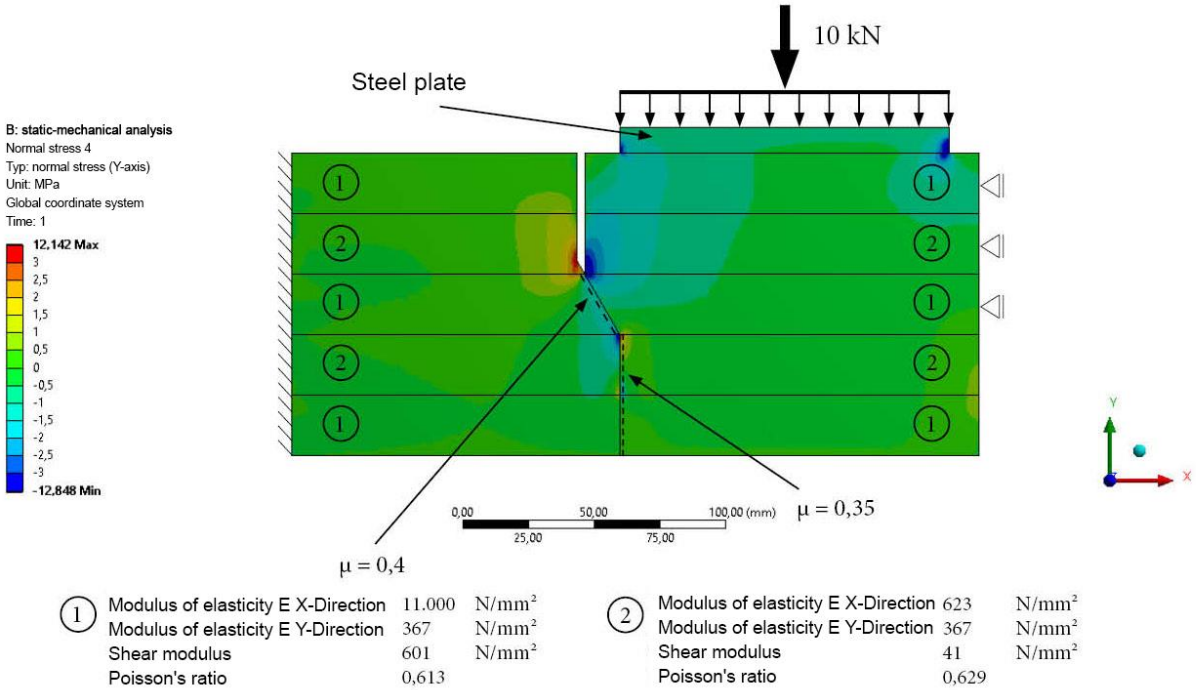

Figure 1: ANSYS follow-up simulation - stress concentrations perpendicular to the plate support direction

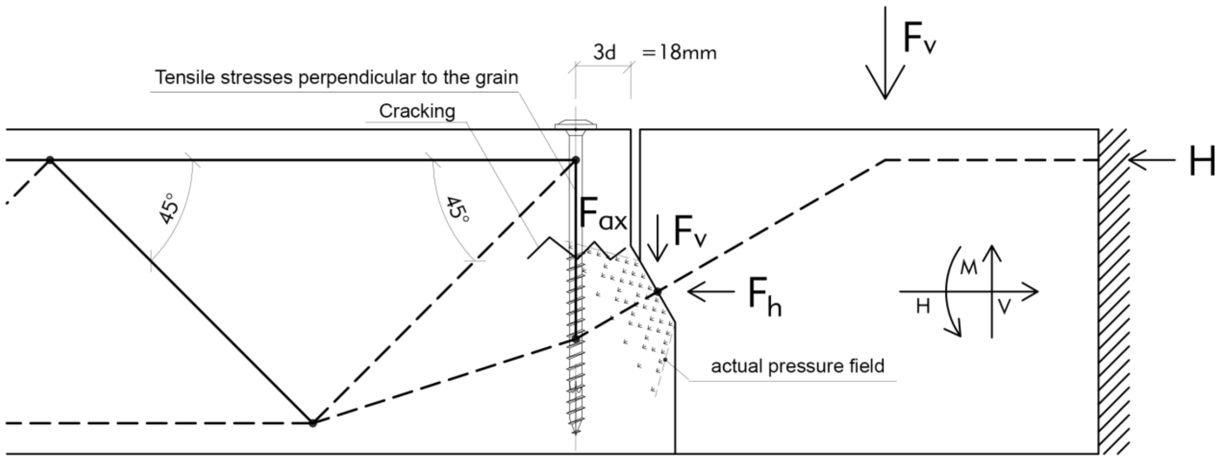

Figure 2: concrete truss model for the distorted state - assumption of a frictionless contact surface

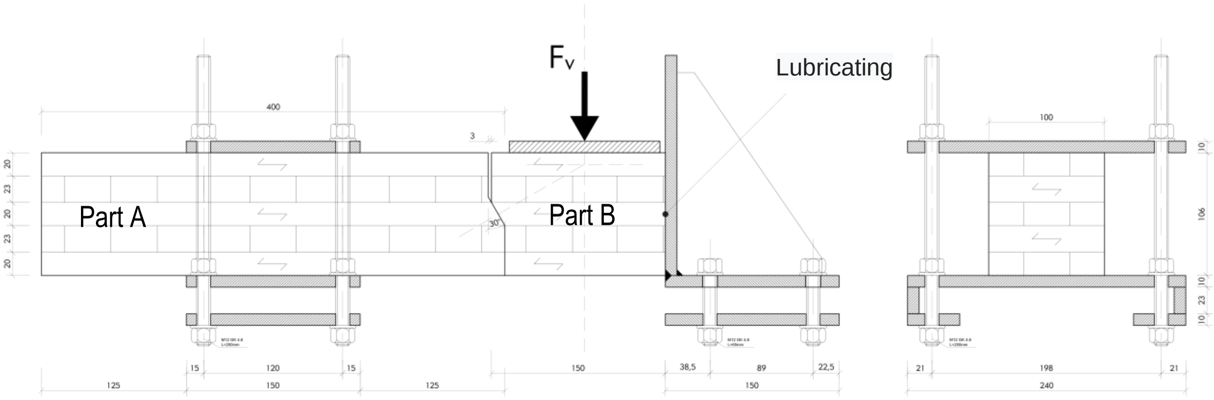

Figure 3: shear test transmission of the shear forces

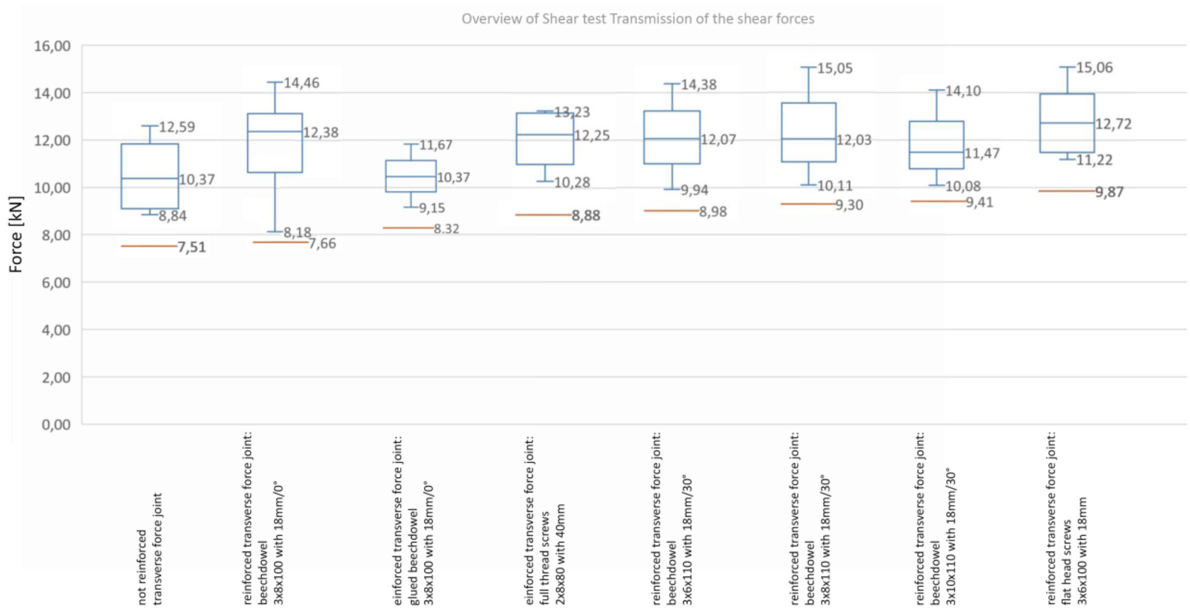

Figure 4: Overview of the shear tests of all test series with max, mean, min values and 5% fractile values

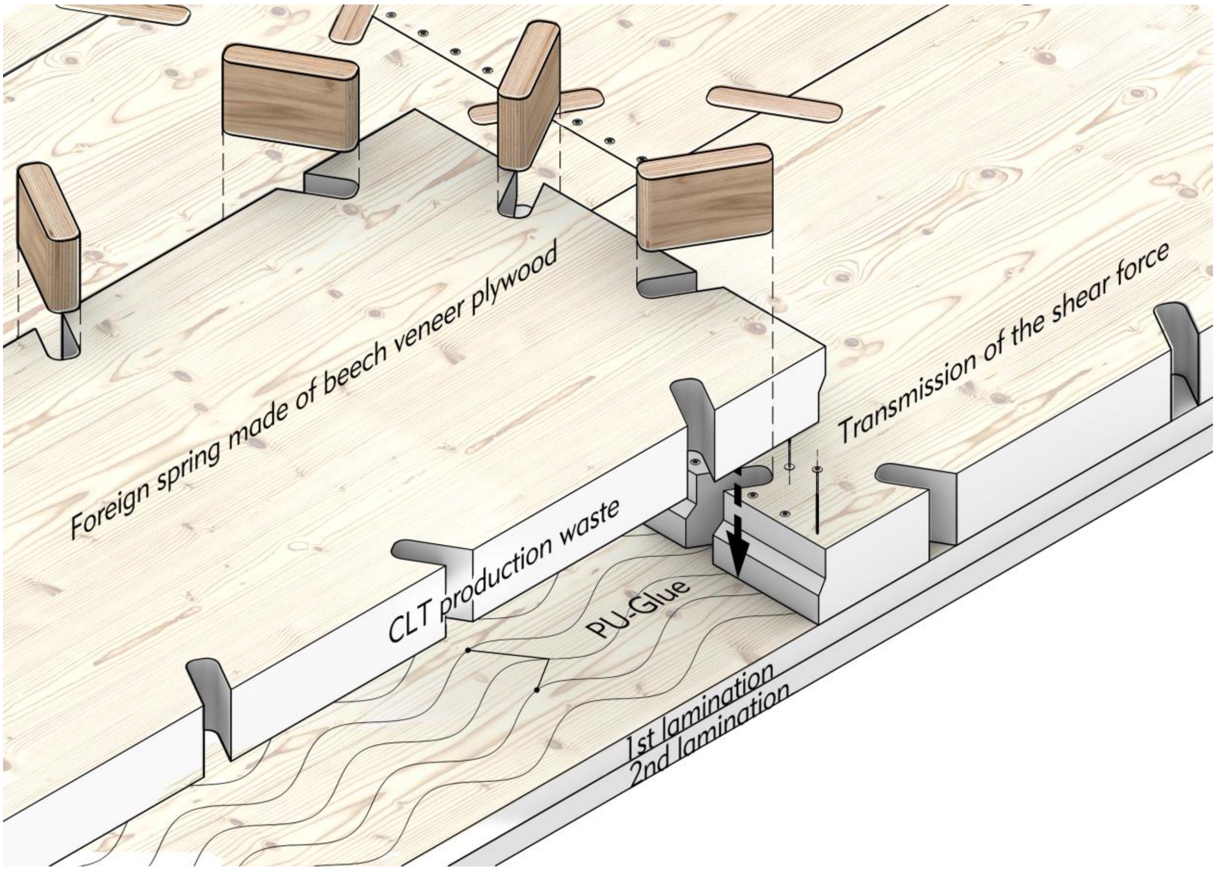

Figure 5: Visualization of the ceiling construction from CLT production waste with additional board layers in the tension zone

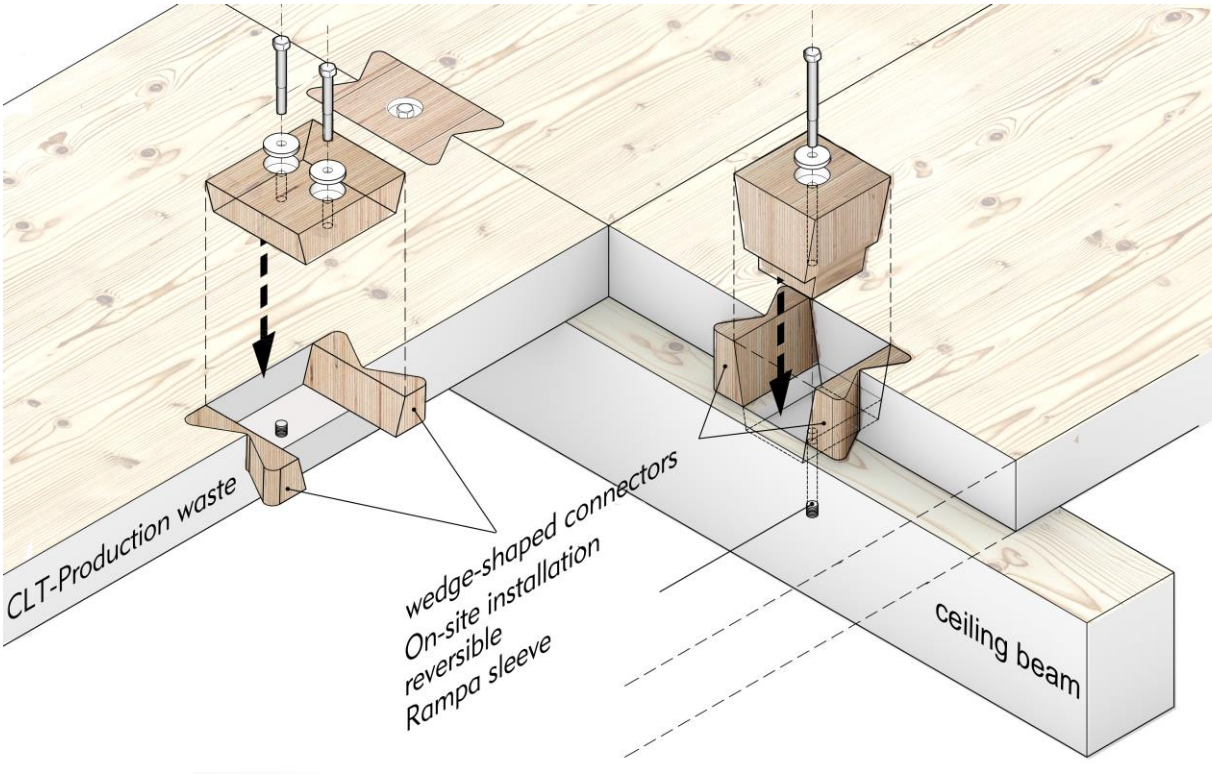

Figure 6: Visualization of the ceiling construction from CLT production waste in combination with ceiling beams

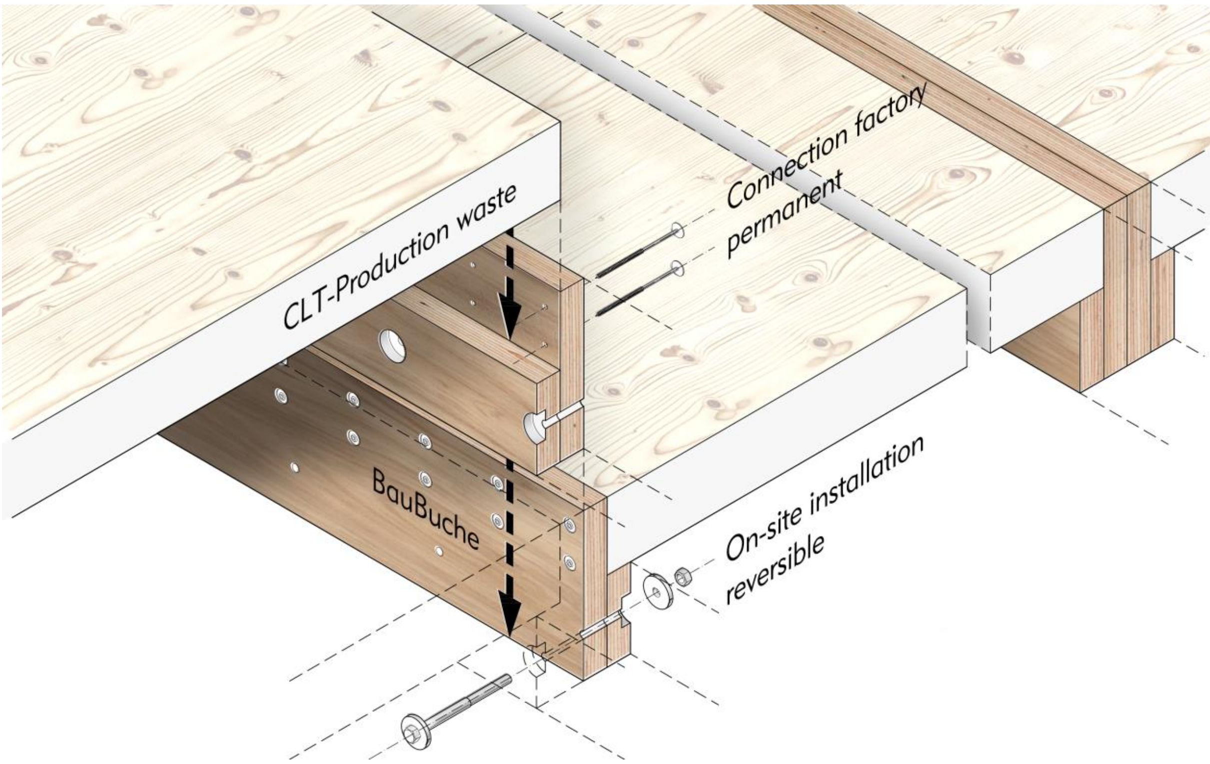

Figure 7: Visualization of the ceiling construction from CLT production waste with high-strength BauBuche beams