Zukunft Bau

SUMMARY REPORT

Title

Reinforcing glued laminated timber with ab initio embedded steel sheets

Cause/ Initial position

In timber engineering the connection bearing capacity is often decisive for the design of the timber sections. Compared to mechanical connections, glued connections have a significantly higher load bearing capacity and rigidity. Glued threaded rods or perforated plates can be used to produce highly load-bearing connections, but the subsequent gluing of the steel parts involves additional effort.

Subject of the research project

The research project involved the investigation of the production conditions and the strength properties of glued laminated steel sheets and their embedding. The decisive factor here is that the steel sheet lamellas were not introduced later but during the production process (ab initio). In this way a production-technological synergy is used, where connection and reinforcing elements, which are connected with a high-strength glue connection, were included into the production of glulam timber elements.

First, preliminary tests were made together with project partners Jowat SE and Pollmann & Sohn. Adhesives (PUR, EP and EPI) and steel sheets types and surfaces (raw, galvanized, smooth and blasted) were evaluated for the suitable steel sheet - timber - adhesive bond.

For the selected combinations the structural behavior of the bond in pull-out tests was determined. The influence of the bond length, a one-sided MUF bonding and a pretreatment of the metal sheets with a primer was taken. Through iterative optimization of the sheet-adhesive combinations, the performance of the bond was able to be improved.

The durability of the bond was determined by cyclic humidification and drying tests. There has been taken the number of cycles until the beginning of the delamination of the bond line. The experiments also included a storage in hot water for determining the influence of temperature on the strength of the bonds. The very different deformation behavior of wood and steel at temperature and humidity fluctuations represents a significant additional load on the composite bond and possibly leads to a significant reduction in load bearing capacity.

The best adhesive-sheet combinations from these experiments were tested under constant load and cyclic climatic conditions in the climate chamber, in order to examine the load-dependent long-term strength (duration of load effect) and the creep behavior of the adhesive bond. A climate change according to DIN EN 15416-3 (45 ° C / 40% RH and 20 ° C / 85% RH) was achieved. Subsequent to the long-term loading, the residual resistance of the remaining samples was determined. Also, additional studies in practical building dimensions are meaningful.

With the project partner Hüttemann, the automated production process of the glulam laminated wood was analyzed and suitable methods and positions for the integration of the gluing of the steel sheets were determined. The possibility for the automation of the required additional manual work steps was developed. The manufacturing process during the gluing of reinforcing steel sheets was tested in construction scale using tension and bending bars. Subsequent machining was also carried out by planning and producing slots and holes for the connections. The required safety distances of the sheets to the wooden surface were determined in order to prevent damage to the trimming tools and the tolerance achieved during the positioning of the metal sheet is determined.

For the reinforced glued-laminated timber with ab initio embedded steel sheets, connection and connection details have been developed: a tension bar connection and moment resistant joint. The force transmission or introduction into the glulam cross-section was effected by means of self-drilling dowels or bolts and slotted sheets or external connected sheets. Due to the choice of the connection, the load-bearing and deformation behavior of the connections could be influenced. By optimizing the embedded reinforcing sheets, a further increase in the load bearing capacity was achieved. Firstly, investigations were carried out on small-sized test specimens in order to be able to estimate the load-bearing capacity and the fracture behavior. Then the connections were tested on laminated wood elements in practical building dimensions. In order to enable the application of the developed reinforcing principle in timber engineering construction, it is possible to derive design proposals for the application of the connections in the construction practice.

Conclusion

For the production of the 'ab initio' reinforced glued laminated timber with embedded steel sheets, adhesive-steel sheet combinations of 2K-EP and 1K-PUR adhesives with blasted or galvanized steel sheets showed the best performance under short and long-term loading as well as climate change. Further investigations are necessary to ensure the durability of PUR bonding. Possibilities for the integration of the steel sheet gluing in the automated manufacturing process were developed and tested and large-sized tension and moment resistant joints were produced. These reached very high load carrying capacities in the tests and demonstrated the performance of the reinforcing and embedding principle for timber engineering construction.

Basic informations

Short title: Glued-laminated timber with steel sheets reinforced

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Total costs: 273.240,48€

Share of federal subsidy: 173.663,96€

Project duration: 24 months

PICTURES/FIGURES:

Bild 1: Bild1.jpg
Test series 4A: Test setup for the tension joint with four self-drilling dowels of the type SFS WS-T 7x153 and slotted steel sheets
Bild 2: Bild2.jpg
Test series 4V: Failure of the specimen PUR- GV-03 through the failure of the adhesive joint
Bild 3: Bild3.jpg
Test series 4V: Preliminary test of tension joint– specimen PUR– PUR- GV
Bild 4: Bild4.jpg
Test series 4A: Failure of the specimen PUR-B-1
Bild 5: Bild5.jpg
Test series 4A: Failure of the specimen PUR-D-1
Bild 6: Bild6.jpg
Test series 4B: Experimental setup overview
Bild 7: Bild7.jpg
Production of the specimens in Hüttemann