Project summary

Title

„Press-fit timber buildings: developing a skeleton construction system“

Motive

The development of a pure wood construction system, which is also suitable for multi-storey residential construction, is intended to demonstrate that high-performance constructions can also be built without being bonded with concrete or steel. In addition, both ecological and economic advantages of the building material wood are presented in comparison to other construction methods.

Subject of the research

The aim of the research is to develop a structural system for multi-storey residential buildings that avoids the use of steel joints and is constructed by means of press-fit joinery connections.

Basic parameters for system development were defined in a concept and development phase. General requirements for timber construction and housing construction form the first framework for the application of the material and the system. With regard to fire protection in particular, the requirements currently determine technical and legal limits for the use of wood in multi-storey buildings. Therefore, only structures below the high-rise boundary are initially considered in the system. The system is also limited to orthogonal geometries.

The constructive implementation of the system was based on historic examples of joinery, common housing construction methods and on the examination of currently available timber construction systems for residential buildings, from which technical possibilities for the manufacture and assembly of the building system were derived. The focus was set on transferring the principles of traditional timber construction to modern wood working technologies. Based on this, the first design variants and joining principles were developed. In addition, design models were created, on the basis of which further system limits with regard to spans and dimensions could be determined. The consideration of the global structure (component level) and the local structure (detail level) are equally important and were taken into account accordingly.

Intermediate results of system development were tested in prototype test setups. Two grid modules were built as a demonstration building. In addition to testing the joining principles and the assembly processes, the suitability for later residential use was also conveyed. After further developments of significant knot details, these were produced as sample pieces, whereby digital joinery technologies and innovative wood connection means were used. From these tests, it was also possible to make initial statements about the time and assembly effort.

The consideration of the global structure was furthered by the development of a dimensioning tool created in Microsoft Excel, with the help of which components of the primary timber construction can be dimensioned. Based on this, approximate amounts of timber for an overall construction can be determined. The tool is primarily designed as a planning aid for the initial application of the building system, but can also be used as an analysis tool for existing buildings. By entering a few building parameters, the most efficient use of the building system can be determined in terms of material consumption, space consumption and utilization.
In the following step, five projects were used as case studies for the implementation of the construction system and analysed with the help of the planning tool. Taking into account the different planning depths, the accuracy of the planning tool was audited on one hand and on the other it could be shown in which cases a high material efficiency can be achieved.

In order to obtain additional knowledge regarding the performance of the pure wooden construction, the interaction of the support system with the formation of the connection details must be considered. For this purpose, based on the model project of an apartment building in Frankfurt (dgj228), implementation variants of the building system were created that include conventional construction methods in combination with concrete or steel. These were first compared in terms of material consumption and costs. In addition, a comparative life cycle assessment of the variants was carried out, thus highlighting the advantages of the timber construction system in terms of environmental impact.

Conclusion

The developed construction system is to be used as an equivalent alternative to conventional construction methods in multi-storey residential construction. On the one hand, the timber construction can meet structural requirements for the structure and also for fire protection. On the other hand, the ecological advantages of the building material wood over steel and concrete could be demonstrated. The potential to reduce the energy and resource consumption of buildings primarily through the selected supporting structure can thus be confirmed.

The construction system can be planned in different variants: as a pure skeleton construction, as a solid wooden construction or as a hybrid construction. The most important connections for the construction system have been proven and described so that they can be used for other projects.

The result of the research is that the developed building system can be easily implemented with today's manufacturing technology. The economic advantages compared to conventional wooden structures could not be demonstrated, but the system is quite competitive with only minimal additional costs and has the potential to become more economical than conventional wooden structures if further optimization is carried out.