TECHNISCHE UNIVERSITÄT KAISERSLAUTERN

BAUINGENIEURWESEN

Fachgebiet Bauphysik /
Energetische Gebäudeoptimierung
Prof. Dr. rer. nat. Oliver Kornadt

Paul-Ehrlich-Straße
Gebäude 29/114
D-67663 Kaiserslautern

Dipl.-Ing. (BA) Tim Schöndube, M.Sc.
Telefon: +49 631 205-5757
Telefax: +49 631 205-4131
tim.schoendube@bauing.uni-kl.de
www.bauing.uni-kl.de/bauphysik

Short report to the research report:

Dynamic thermal-hygric behaviour of solid constructions: Development of a heat storage capacity index for buildings made of masonry and thermally activatable solid timber elements

Title

Dynamic thermal-hygric behaviour of solid constructions: Development of a heat storage capacity index for buildings made of masonry and thermally activatable solid timber elements

Motive / Starting position

The thermal storage capacity of building constructions can have a significant influence on the energy consumption and the thermal comfort of buildings. Within the context of increasing requirements for energy efficiency and user comfort of buildings the intrinsic properties of buildings due to their construction method have to be given greater consideration, besides the improvement of insulation systems and systems for energy provision. In the course of increasingly accurate calculation and accounting methods, it is necessary to take into account the influence of the heat storage capacity of a building on the energy demand.
The research project addresses this issue by examining and evaluating the impact of the heat storage capacity on the thermal behaviour of buildings.
Furthermore, the consideration of the heat storage capacity is becoming increasingly important also for modern timber constructions. The introduction of solid cross-laminated timber construction systems combines the opportunity of fast construction with the effect of using the advantages of thermal storage mass on the energy demand and the thermal comfort.
Therefore, in this project the feasibility of a surface heating and cooling system integrated into the elements of solid timber buildings with exposed wooden surfaces, is examined.

Topic of the research project

Aim of the research project was on the one hand to develop a heat storage capacity index for buildings, which enables statements about the influence of the heat storage capacity on the net energy demand for heating, the summer overheating potential and the thermal comfort, without complex simulation calculations. For this purpose, test buildings made of different exterior wall constructions were built and monitored over a year, applying different controlled heating and ventilation programs. Simultaneously, simulation models of the test building were created. For the validation of the models, the simulation results were compared with the corresponding measurement data. Subsequently, thermal simulations for a representative apartment building were performed. Within the scope of a variant analysis, different practicable

constructions of the opaque components and various measures for summer heat protection were chosen. For selected rooms of the apartment building, simulation results were evaluated and conclusions were derived. Based on the results, heat storage capacity indices were developed.
On the other hand, the feasibility of a surface heating and cooling system integrated into the elements of solid timber buildings with exposed wooden surfaces was examined in this project. To begin with, material data for the development of a numerical construction model of the thermally activated solid timber elements were collected. Missing data were generated in preliminary tests and were considered during the further development. After discussing possible system buildups and a possible production process, two prototypes of thermally activated solid timber elements were produced, on which comprehensive laboratory tests were made. As a result, a feasibility study was possible. Moreover, the collected measurement data were used for validating the developed numeric dimensioning model.

Conclusion

The research work led to the insight that the higher the effective heat storage capacity of a building is, the lower is the net energy demand for heating. For buildings with extremely heavy construction compared to extremely light construction, a maximum 9 % lower annual net energy demand for heating was determined. It is worth considering whether this effect should be taken into account in standardisation or in the Energy Saving Ordinance. Moreover, it has been shown for buildings without construction measures for summer heat protection that the higher the heat storage capacity is, the less is the risk of summer overheating. Besides, for buildings without external shading devices an improved thermal comfort during summer can be expected when using constructions with a high effective heat storage capacity. When adhering to the requirements regarding summer heat protection in DIN 4108-2, no significant influence of the heat storage capacity on the summer overheating risk and the thermal comfort could be detected.
Furthermore, the examinations showed that there is more need for research. Especially more examinations are useful to extend the validity range and the precision of the developed heat storage capacity indices. On the one hand, further simulation studies are provided outside the project for this purpose. On the other hand, it is planned to continue the research on the test buildings, in coordination with the project partners.
Moreover, the feasibility of air-guided thermally activated solid timber elements as a panel heating and cooling system was proven within this research project. For the manufacturing of the elements existing production facilities can be used. Need for optimization is seen when applying adhesive and when milling the integrated ducts. More effective cutting tools should accelerate the milling process. In all layers narrow side glued board layers should be used for the production.
For use as a wall element double harp-shaped ducts are suitable. This layout offers the advantage that the development of the elements is possible in the floor construction. To achieve high performances and short thermal response times the ducts should be in shallow depth under the wood surface. A necessary minimum thickness ensures the airtightness and should be at least one uninterrupted narrow side glued board layer.
The maximum achievable heating and cooling output of the tested Prototype B depends on the flow temperature and is limited by the resulting wood moisture. Experiments and simulations have shown that a heat output of 47 Watt per m² element surface at a room air temperature of 20 °C and 50 % relative humidity is permanently possible without impairment of the solid timber elements. This requires flow temperatures of the system air of maximum 45 °C. When the ambient climate is under 30 % relative humidity the permanent permissible heat output should be reduced to avoid shrinkage cracks on the element surface.
In cooling mode, a permanent performance of 24 Watt per m² element surface should not be exceeded to avoid wood moistures over 20 percent by weight.
The developed numeric dimensioning model was validated by comparison with the laboratory measuring data and can be used for the further optimization of the system and to plan thermally activated solid timber elements for concrete applications.

Additional research is required to optimize the fluid mechanics of the duct system and to develop a standardized air conditioning plant for the system air.

Key data

Short title: Heat storage capacity

Researcher / Project management:

Prof. Dr. rer. nat. Oliver Kornadt (responsible person)	Technische Universität Kaiserslautern
Dipl.-Ing. (BA) Tim Schöndube, M.Sc. (project manager)	Technische Universität Kaiserslautern
Jun.-Prof. Dr. rer. nat. Svenja Carrigan	Technische Universität Kaiserslautern
Saif Rashid, M.Sc.	Technische Universität Kaiserslautern
Univ.-Prof. Dr.-Ing. Stefan Winter (responsible person)	Technische Universität München
Klaus Mindrup, M.Sc.	Technische Universität München

Practice partners:

Dipl.-Ing. Torsten Schoch	Xella Technologie- und Forschungsgesellschaft mbH
Dipl.-Ing. Franz Loderer	Xella Technologie- und Forschungsgesellschaft mbH
Dipl.-Ing. (FH) André Staniszewski, M.BP.	Arbeitsgemeinschaft Mauerziegel e.V.
Dipl.-Ing. Juliane Nisse	Arbeitsgemeinschaft Mauerziegel e.V.
Dipl.-Ing. Hans R. Peters	Mein Ziegelhaus GmbH & Co. KG
Dipl.-Forstw. Christof Richter	Binderholz GmbH

Total costs:	355.336,90 €
Share of federal grant:	244.978,00 €
Project duration:	33 months