Zukunft Bau

STRUCTURE / STRUCTURE SHORT REPORT

Title

Large scale demonstrator – Multifunctional precast concrete elements for energetic usable building structures

Motivation/ starting position

Renewable energies fluctuate and must therefore be stored for their effective use. Active solar houses use large water storages within the building envelope for this purpose. Practical examples show that this concept works and allows high shares of solar heat. This is opposed by the comparatively high production costs and the high demand on space. Alike water storages, the buildings structure has the ability to store heat.

The subject of the research project

This research project deals with the development and implementation of the large scale demonstrator Smallhouse IV. A building energy concept is developed which actively uses the building mass for heat storage. Similar to active solar houses, the entire heat supply is to be guaranteed by means of a minimum primary energy demand. For this purpose, however, the solar heat is not to be stored in oversized water storages but in the available building mass. For this purpose, thermally activated precast concrete elements are developed, which, in addition to their static functions, also perform the thermal functions of thermal insulation, heat storage and indoor temperature control. These components are referred to as multifunctional precast concrete elements.
Within the framework of this research project, the large-scale demonstrator "Smallhouse IV" is built on the campus of the TU Kaiserslautern to investigate the effectiveness of the multifunctional precast concrete elements. It consists of three different components: the floor slab, the outer walls and the ceiling elements. Each of these components is designed as a multifunctional component with different thermal functions. In addition to their static-structural functions, the core-tempered outer walls of the large demonstrator are to be used for heat storage and temperature control of the interior space. In order to achieve a heat storage effect, the components are core-tempered in order to release heat from the collector to the interior with a time delay. The task of the near-surface activated base plate is the temperature control of the interior with a short time delay. While the exterior walls are primarily intended to cover the basic load of the building, the activation in the base plate ensures that the peak load is covered. Like the outer walls, the ceiling elements are also manufactured as sandwich elements and are thermally activated on the outside within the facing shell. In addition to their heat-insulating function, the ceiling elements thus function as solid absorbers for heat supply.
The preliminary investigations show that the basic idea of the concept of storing heat from renewable energies in precast concrete elements is possible. The simulations showed that by using the outer walls as heat storage and a minimum water storage, the large-scale demonstrator achieves a solar coverage of approx. 50%. In addition to the type and nature of the multifunctional components, the control concept is the most important factor. A comprehensive monitoring concept enables measurement of interactions between the heating system and the components in a real operation state, even beyond the scope of this research project.
This report? describes the entire process from design to construction. The first part deals with the conceptual design and the structural design of the building as a sandwich structure. Based on this, the planning is completed in an iterative process by means of static dimensioning and thermal simulation. Followed by the energetic investigation of the thermally active sandwich components and their integration into a building energy concept. Using a transient building simulation, the concept is evaluated on the basis of characteristic values and the interaction of component, control and building is investigated. One result is the potential of the heat storage capacity of the building mass in comparison to conventional building concepts. The report closes with the documentation of the production process and the assembly of the thermally active concrete sandwich elements.

Summary

All work steps, from planning through static and thermal dimensioning to production, were successfully completed. The large-scale demonstrator Smallhouse IV was implemented on the premises of the TU Kaiserslautern.
It was shown that the entire manufacturing process of the multifunctional components, from prefabrication in the plant to dry mounting on the construction site, is economically and technically feasible.
By active incorporating of the building structure into the heat storage system, it is possible to resign from large water storage volumes or to minimise them. The computational comparison of the Smallhouse IV with the heat storage in the building structure compared to the heat storage in a water storage tank, results in an equivalent water storage size of the multifunctional outer walls of 2,000 l. The water storage capacity of the building can be calculated from the heat storage capacity of the building structure.

Basic data

Großdemonstrator Smallhouse IV

Project Management:
Prof. Dr.-Ing. Matthias Pahn
Prof. Dipl.-Ing. Dirk Bayer
Prof. Dr. Sven O. Krumke
Researchers:
Dipl.-Ing. Christian Caspari
Dipl.-Ing. Tillman Gauer
Dr. Michael Holzhauser
Dipl.-Ing. Dirk Miguel Schluppkotten

Total cost: 339,506.75 €

Share of federal subsidy: 183,720.00 €

Project duration: 32.5 months

Visualisation:

Picture 1: Production of the facing wythe in stand production in the precast factory

Picture 2: Production of the core-tempered load-bearing wythe in stationary production in the precast factory

Picture 3: Assembly of the first multifunctional precast concrete element

Picture 4: Assembly of the second multifunctional precast concrete element

Picture 5: Dry jointing of two multifunctional precast concrete elements

Picture 6: Shell construction state of the large demonstrator Smallhouse IV