Short summary

Title
"Efficient internal insulation with enhanced heat capacity"

Initial situation
For the implementation of the energy transition the increase of building energy efficiency is necessary. Thermal insulation composite systems are suitable for outer walls. Significant reductions of the thermal losses are possible.
Nevertheless, thermal insulation composite systems are not suitable for many existing buildings, for example, because of monument conservation reasons. About five percent of the buildings in Germany constructed before 1978 are partly or fully listed. In these cases, an energetic optimization is only possible with internal insulation systems. Compared to external insulation systems these systems have some disadvantages.
The most important disadvantage is that the thermal capacity of the outer wall is not working any more. In consequence of that, there is a growing risk of summer overheating.

Aim of the research project
In course of the project the use of phase change material (PCM) for summer heat protection and heat loss reduction during spring and fall was examined.
Therefor an internal insulation system with PCM plaster was developed. Focus of the project was the development and optimization of the insulation system.
With the help of adding PCM to the plaster mixture the thermal capacity increases and the temperature rise can be buffered more effective.
In a first step simulations have been run. Different thicknesses of the PCM layer, different air exchange rates of the building and different PCM plaster compositions were examined.
It was determined that a heat loss reduction is possible if an optimized PCM material is used.
For the examination of the best capabilities simulations with special weather data have been run (very hot summer days and warm fall days followed by a cold snap). Different thermal conductivities and different layer thicknesses were considered. The result of these simulations was that the use of PCM is more suitable for summer heat protection. A significant reduction of hours with unacceptable high room temperatures was possible by using the new developed system.
With the help of a 2 cm thick PCM plaster a reduction from 49% to 10% hours with unacceptable high room temperatures was determined.
Thicknesses above 3 cm weren't able to use their full potential. The intrusion of heat took too much time. The conclusion is that plaster thicknesses from 1 cm up to 3 cm are suitable.
Experimental investigations have shown that the maximum share of PCM in a plaster mixture is 30%. Plaster with higher concentrations has no satisfying structural properties.
The validation of the simulation model was realized with the help of three test walls. All three walls were made of sand lime bricks. One test wall was without insulation like a typical wall of an old building. One test wall was constructed with an internal insulation with PCM plaster and one test wall was constructed with an internal insulation with a normal plaster.
Every test wall was part of a 1 m^3 large box. The rest of the boxes were build out of extruded polystyrene foam (XPS). It was possible to regulate the climatic conditions inside the boxes. In and around one box were 14 temperature sensors installed (Pt 100, class A). The temperature was measured in different depths of the sand lime brick walls, inside and outside of the insulation and on the outside of the plaster. There also were two installed sensors per box for recording the air temperature and a weather station for measuring the outside climate.
The test beds confirmed the simulation results. The importance of the air exchange rate for the regeneration of the PCM plaster was shown once again. During the test schedules different user behaviors and their influence of the system efficiency were detected.

Conclusion

For a successful use of the new insulation system it is necessary to guaranty the phase change of the PCM. That means that the phase change temperature must conform to the temperature boundary conditions of the installation situation and the ventilation rate by night must be strong enough to unload the PCM again.

It was determined that the new insulation system is able to compensate the loss of thermal capacity as a result of using internal insulation.

Using the PCM plaster with 30% PCM share, a significant reduction of hours with uncomfortable high room temperatures is possible also compared to an outside insulation.

Basic information

Short title: InDäS

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Governmental share: 118.191,522 €

Project term: 31 months