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Monitoring of indoor climate conditions in earth buildings – Comfort control through material properties

This paper reports on the joint research project "Monitoring trifft Befragung – Monitoring des Innenraumklimas in Gebäuden verschiedener Lehmbautechniken im Bestand und Neubau unter Einbeziehung der Bewohnerperspektive – MoBeLe" (Monitoring and user surveys – monitoring the indoor climate of new and existing buildings made with various earthen construction techniques, including the residents' perspective) funded by the German Federal Ministry of Education and Research and undertaken by the WIR-Bündnis GOLEHM-Initiative (www.golehm.de).

The project partners are the IBQS Institute for Quality Management in Building Physics at Erfurt University of Applied Science, the Institute for Psychology at the University of Halle-Wittenberg and the LENA State Agency for Energy in Saxony-Anhalt.

The research project is a broad-scale study of indoor climate conditions in various buildings constructed as massive earth structures. This paper examines the interim results from the first phase of monitoring the indoor climate conditions in various buildings constructed as massive earth structures.

This paper examines the interim results from the first phase of monitoring results and the initial conclusions that can be drawn from them, especially with a view to increasing public awareness of such resilient construction technologies in modern construction.

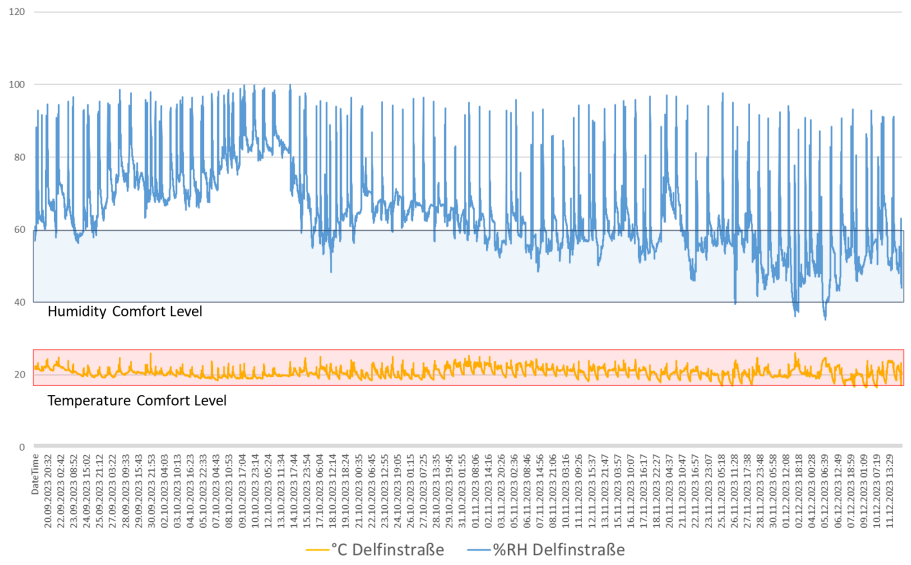
Background

Earthen materials have been used across the globe for building since the first settlements in human history. In Germany, earth building techniques are thus also a common characteristic of traditional buildings in Germany. In the study region of the research project in Central Germany, monolithic earth building techniques, such as cob, rammed earth and earth masonry, are particularly prevalent. It is estimated that there are around 200,000 such buildings in this area of Germany [1].

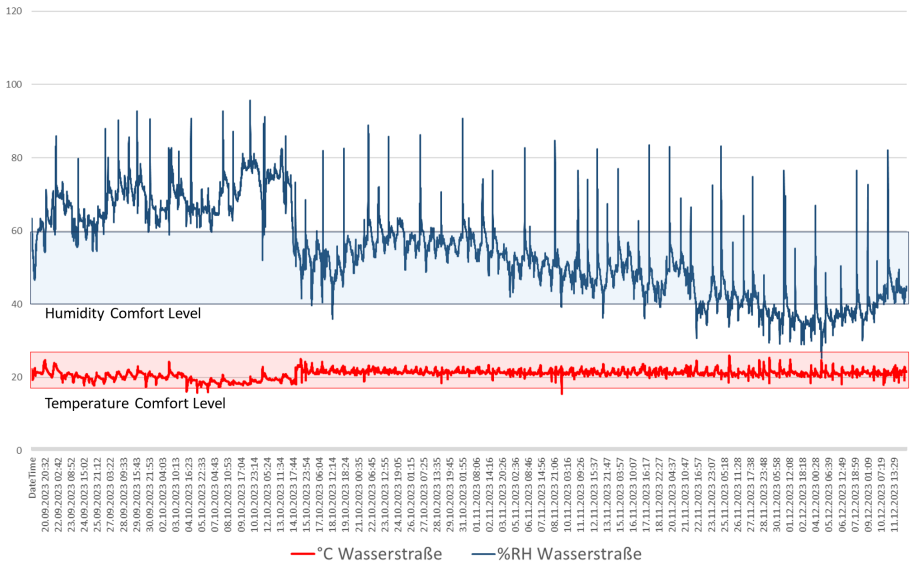
Alongside the heritage of existing traditional buildings, we are also seeing an increase in interest in ecological building by environmentally conscious architects and builders as well as clients who choose natural building materials for their contribution to tackling climate change, their low carbon emissions and their beneficial properties for healthy indoor environments.

01 Preparation of measurement points inside a building

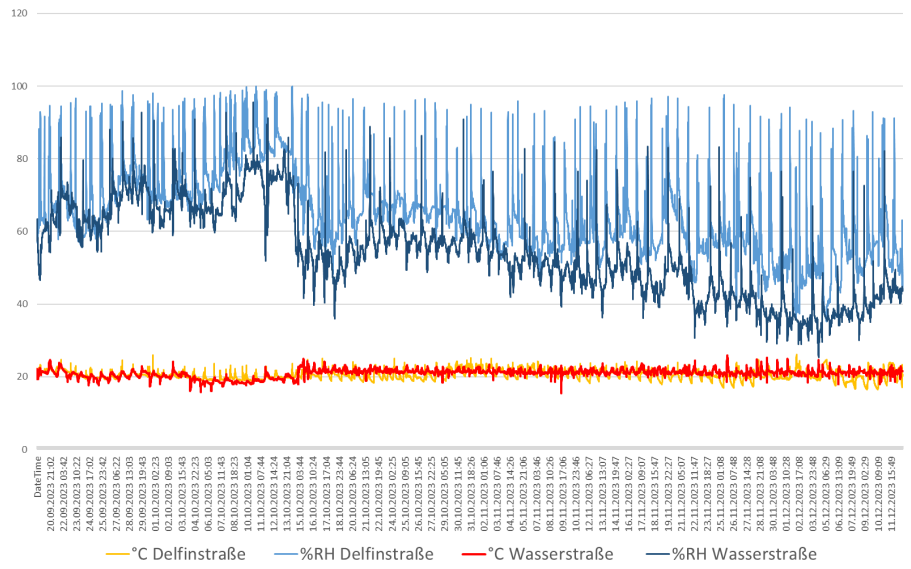
02 Measurement point in a fully tiled bathroom



03 Indoor climate values for a fully tiled bathroom (September to December 2023)



04 Indoor climate values for a bathroom with partial earth plaster surfaces (Sept. to Dec. 2023)



05 Overlaid results for indoor climate values for the two bathrooms (Sept. to Dec. 2023)

Until now, however, the positive properties of such earth building materials and their contribution to creating a comfortable indoor climate have not been corroborated at a broad scale through scientific field recordings.

Research method

Research setup

The first step was to identify relevant buildings together with the consortium of the WIR-Bündnis GOLEHM-Initiative. Owners and users (residents) of monolithic earth buildings within the study region were informed of the research project and invited to participate in field recordings of their indoor climate conditions, accompanied by a parallel survey of their subjective well-being. For each of the chosen objects of study, a plan for the long-term-monitoring of the indoor climate was devised, including listing measuring points and devices placed in the relevant buildings. To provide control values, other reference objects in the same area built using conventional building techniques were also monitored.

Comparison of results

To obtain comparable results from the survey, we identified pairs of buildings situated in the same location, of the same size and use that are subject to the same local weather conditions as given in the weather database Copernicus. Parallel to installation of the measurement points on site, we collected key parameters for each situation, such as room size, wall construction, surface materials, orientation, etc. on a documentation sheet. This allowed us to evaluate the reasons for different climate conditions within the buildings.

Analysis

Comparisons between the first results of bathrooms in two buildings has shown that surface materials have a significant impact on the humidity buffering capacity. A bathroom clad almost entirely in ceramic tiles exhibits significantly higher values of relative humidity than a comparable bathroom with a larger proportion of earth plaster surfaces (Figures 3 and 4).

Neither of the bathrooms has any additional ventilation systems. While the temperature values remain more or less within the comfort zone (around 20 °C) in both bathrooms, the relative humidity readings for the fully tiled bathroom are significantly higher at around 75 %, peaking up to 100 %. The bathroom that is partially coated with earth plaster exhibits a buffering effect, and high peak relative humidity values are minimised.

Conclusion

This paper reports on the first results and analysis of a three-month monitoring period. After more extensive long-term monitoring, we expect to observe a wider spread of temperature values, especially in the summer period. Alongside temperature and relative humidity values, the monthly energy demand for each building is also being monitored to analyse the correlation between weather conditions, energy demand for heating and cooling and passive low-energy performance of the various building types.

We are convinced of the potential of earth building materials in the context of passive low-energy architecture and hope through our research to demonstrate the viability of massive earth building techniques, and to raise public awareness of the potential of such resilient construction methods for modern-day construction.

References

[1] WIR-Bündnis GOLEHM-Initiative *https://www.golehm.de/massivlehmbau/atlas-massivlehmbauten-in-mitteldeutschland*, last accessed: 26 August 2023.

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