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Fraunhofer Institute for Building Physics IBP

Research, development, demonstration and consulting in all areas of building physics

Approval of new construction materials, components and design methods

Officially approved test, monitoring and certification organization

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Short IBP-Report HTB-029E/2019 of IBP-Report HTB-023/2019

Damage-free energetic window renovation in old and listed buildings

Bundesinstitut für Bau- Stadt- und Raumforschung (BBSR) Forschungsinitiative Zukunft Bau (Aktenzeichen: SWD-10.08.18.7-17.42)

The report contents
7 pages text
5 pictures

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Inhalt

1 Starting position

Historical windows worthy of preservation are an integral part of the cityscape and shape the surroundings of a district. The wishes of the house users (tenants, owners) for comfort and energy saving as well as the political goals of the federal government for energy saving (e.g. energy saving regulation EnEV) are important framework conditions. The maintenance and renovation of existing windows depends above all on the durability and usability of the renovation measure and the achieved energy standard. The aim of the research project is to make the energetic refurbishment of sustainable existing windows safer and thus preserve historic windows, prevent damage, promote energetic refurbishment and increase the market share of specialized window manufacturers. This is achieved by the targeted research of the essential parameters U-values of window pane combinations, air exchange conditions and the hygrothermal conditions resulting from this in the course of the year.

2 Object of the research project

For the selection of the renovation variants, student preparatory work has already been carried out at the IBP. On the basis of this preliminary work and intensive evaluation of the existing literature with supplementary literature research, suitable variants for the energetic renovation of existing windows were preselected in work package 1 (renovation variants – selection of the system). Intensive coordination conversations and working meetings were held with the participating window manufacturers to define and select suitable renovation solutions.

In work package 2 (installation and measurement), the installation of the selected renovation solutions and measurement sensors took place at the Fraunhofer Centre for energetic renovation of old buildings and preservation of monuments in the Old Cooperage at Benediktbeuern monastery. Three existing windows were extended to a box-type window. This allows comparative investigations carried out with different sealing concepts. The sensors necessary for assessing energy efficiency, hygric and hygienic conditions were installed on the wall or window surfaces and in the interior of the box-type window. The outdoor climate was measured with air temperature, relative humidity and global radiation. The results of all sensors were connected to a data acquisition system and permanently stored in the IMEDAS® database. The measurements could thus be monitored online and downloaded for processing. The energetic effects of the refurbished window solutions were documented with high-resolution IR thermography at suitable outdoor conditions.

On the basis of the refurbished window F 1.26 a 3D corpus model in WUFI® Plus was created in work package 3 (computational investigations). For this, the real conditions in the software had to be simplified. By appropriate modeling, the essential mechanisms for the air exchange in the cavity of the box-type window could be implemented.

The recorded measurement data were prepared and graphically displayed. Analyses of times with condensate at the measuring points were carried out. The measured data were used for the simulation as boundary condition for the box-type window model created in work package 3. The measured values were compared with the calculation results in work package 4 (evaluation of measurement and calculation). The effects on the hygrothermal behavior in the cavity in the box-type window could be investigated by varying the boundary condition using the validated simulation model. In variant investigations, the mixed air change rate from infiltrated room air and outside air in the box-type window cavity were calculated. From these calculations, parameters for the inner and outer tightness levels could be derived. In addition, the effects of selected climatic regions (Benediktbeuern; Hamburg) on critical situations were investigated.

The results will be presented at the Fraunhofer Centre for energy efficiency and renovation of old buildings and monuments in Benediktbeuern as well as at conferences and meetings (AP 6). In addition, publications on the topic are planned in the relevant media of the industry (e.g. journal Bausubstanz, IRB Verlag).

3 Conclusion

The air-tightness and U-value of the two window levels of the box-type window is of decisive importance for the humidity conditions in the cavity, in addition to the indoor and outdoor climate. The comparison of the three box-type windows, which were measured in detail, results in different mixing ratios in the cavity depending on the tightness. The calculated mixing ratio from the moisture measurement can be confirmed by determining the exchanged air volume using tracer gas measurement.

The detailed calculation of the thermal bridges and the resulting U-values of the overall construction as well as the linear thermal bridge heat loss coefficients result in a reliable estimation of the actual thermal behavior of the windows.

Hygrothermal calculations with WUFI® Plus are carried out to investigate the effects of different refurbishment variants on a box-type window. Based on the measured values, a box-type window model is created to calculate the local climate in the cavity as a function of the flow conditions, U-values and the indoor and outdoor climate. Thereby, the general effect of changed tightness on the humidity conditions in the cavity can be confirmed. The simulation of the effects of different U-values of the window levels on the humidity conditions in the cavity result in new findings.

4 Basic information

Short title: Windows in historic buildings

Project leader: M.Eng. Stefan Bichlmair (Projektleiter)

Total cost: 202,207.00 €

Quota of Federal grant: 138,207.00 €

Project time span: 24 month

5 Picture

Bild 1:
(Bild1_Ansicht_Bestand.jpg)
Old Cooperage upper floor window 1.26 north side: Outdoor and inside view, existing window previous state. Dimension 1.14 m x 1.40 m (1.60 m²).

Bild 2:
(Bild2_Ansicht_innen_Kastenfenster.jpg)
Old Cooperage upper floor window 1.27: Inside view, with extension to box-type window. Left picture window closed, right picture with open inner window sash.

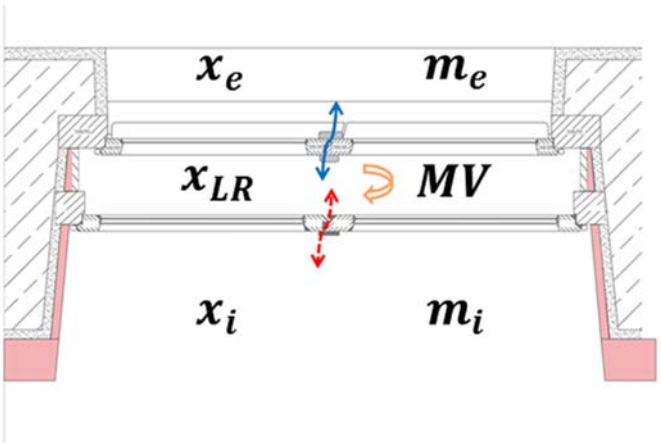


Bild 3:
(Bild3_Mischungsverhältnis_Schema.jpg)
Horizontal cross section of the box-type window with designation and allocation of the physical quantities for the determination of the mixing ratio (MV) of the air humidity and air masses.

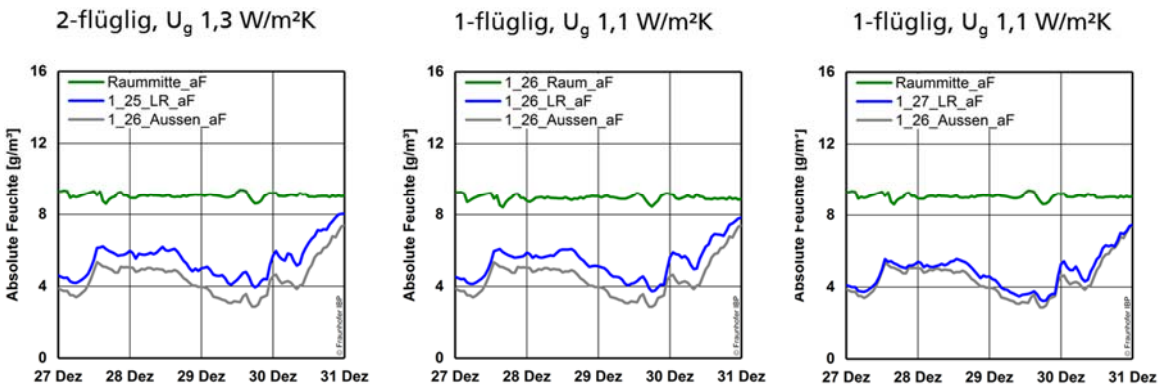
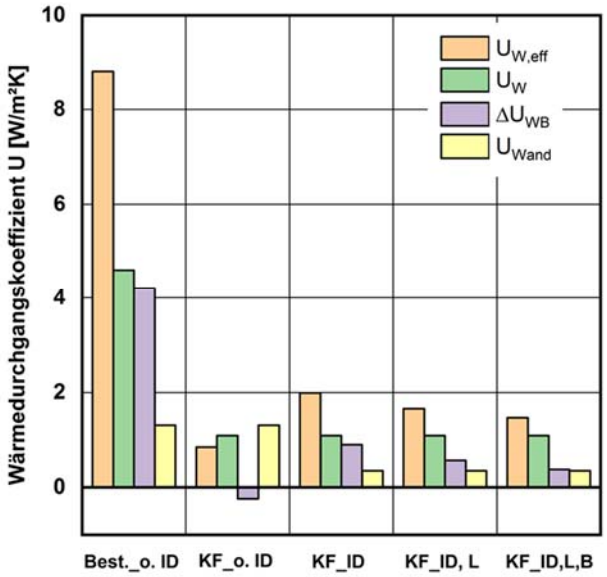


Bild 4:
(Bild4_Absolute_Feuchte_Kavität_Vergleich.jpg)
Measurement results of the absolute humidity in the cavity (LR_aF) of the windows 1.25, 1.26 and 1.27 located at the north side of the upper floor. Additionally, the absolute humidity of the indoor and outdoor climate is also drawn in the diagrams.



Fenster F 1.26		Bezeichnung im Diagramm
Mit Innendämmung und:	ohne seitl. Laibungsdämmung Dämmung am Sturz ohne Brüstungsdämmung	**KF_ID**
	Dämmung in Laibung Dämmung am Sturz ohne Brüstungsdämmung	**KF_ID,L**
	Dämmung in Laibung Dämmung am Sturz Dämmung Fensterbrüstung	**KF_ID,L,B**
Kastenfenster ohne Innendämmung		**KF_o. ID**
Bestand ohne Innendämmung		**Best._o. ID**

Bild 5:
(Bild5_U-Werte_Varianten.jpg)
U-values of the different variants of the refurbished window F 1.26 and outer wall (left diagram in the picture). In the table, the abbreviations of the diagram are explained.