



Material data for energy-oriented refurbishment of old buildings

Figure 3



- ▶ Detailed material knowledge for the prevention of moisture damage
- ▶ Physical standard characteristics of traditional and modern construction materials online
- ▶ On the way to a new characteristic value: the drying characteristic value

Top and bottom right: Indoor mould infestation – the building was equipped with a 6 cm-thick insulation 15 years ago. The insulation was insufficient from a building physics point of view. Bottom left: Microscopic photograph of a typical indoor mould: *Alternaria alternata*

The stock of old buildings, which constitutes approximately 80% of all buildings, has the greatest potential for reducing energy consumption. Major energy savings can be made in this area through construction measures such as thermal insulation, the use of solar radiation or the improvement of the interior climate through heating, ventilation or cooling. Since the Energy Savings Ordinance came into force in February 2002, guidelines on energy-related and structural thermal protection also apply to the renovation of old buildings. This makes the planners' task more complex. While builders are usually more interested in finding the most cost-effective solution to complying with regulations, it is the planners who, with the same intention, have to implement the renovation measures for specific stocks of buildings. Unprofessional and physically flawed renovation of buildings can cause serious damage.

Problems often occur with the renovation of old buildings, such as mould formation or corrosion, which usually stem from limited

knowledge of the moisture characteristics of the construction materials used in the original construction and those used today. Often construction physical properties of modern products are attributed to the historical materials discovered in the building stock. The selection of materials used for repair work is correspondingly limited. Until now there has been a lack of an interlinked and extensive collection of hygrothermal material characteristic values, which can also be used as the basis for the available planning software.

A detailed description of the building climate characteristics of as many construction materials as possible would provide a sound basis for correct renovation in terms of building physics. This information gap will be closed by a research project sponsored by the Federal Ministry of Economics and Technology. The aim is provide users and producers of planning software with a database as large as possible on the material characteristics of historical and modern construction materials and make this database freely accessible on the Internet.

► Material data collection

Materials have been selected which can be considered representative in terms of energy-oriented refurbishment of old buildings. The result is a catalogue structured according to categories – such as bricks, plasters or timbers. The specific construction materials under investigation are allocated to these categories.

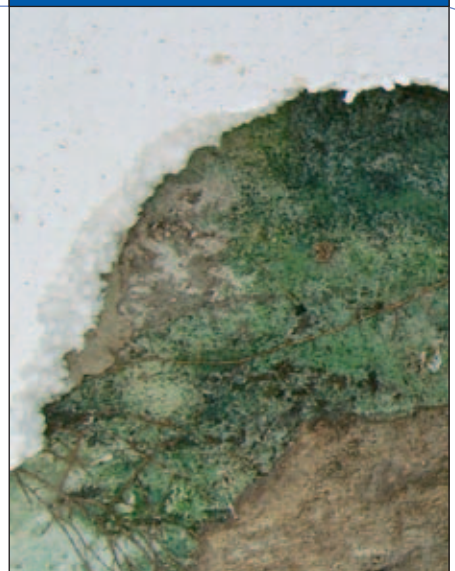
Besides familiar construction materials, materials are also represented which are no longer in use but which could be contained in the substance of old buildings – e.g. broken-brick concrete as an important construction material in the post-war period. Other construction materials are used today using historical records – but differ in their composition and manufacturing technology from the old construction materials.

Figure 2: Material characteristic values

Thermal characteristic values	Hygic characteristic values
Specific thermal storage capacity	Diffusion resistance coefficient
Thermal conductivity	Sorption
	Water absorption coefficient
	Free water saturation
	Open porosity

Determining the characteristic values: Besides the bulk density of the construction materials, this also involves thermal and hygic characteristic values, which are generally determined by measurement. For some construction materials the characteristic values can be taken from the descriptive literature..

Figure 3: Algae infestation beneath Styropor insulation



► Establishing a drying characteristic value

Closer examination of building physics standard characteristic values shows that to date these do not sufficiently characterise the hygrothermic behaviour of construction materials. The established water absorption coefficient (w value) describes the absorptency of liquid water, while the diffusion resistance coefficient (μ value) or the diffusion equivalent air layer thickness (sd value) expresses the drying possibilities through diffusion. These values do not allow for the influence of the capillary conductivity of a material on the drying process.

The following example presents the problems arising from the approach taken to date: It shows that two plaster systems, despite having almost the same w and sd values, have significantly different drying characteristics. While the one plaster system dries much more slowly in high humidity, the influence of humidity on the drying rate of the other plaster system is relatively low. The reason for this is the different interaction of diffusion and capillary transport. The second plaster

system has far greater capillary transport during drying. Here the drying conditions which are made worse by higher humidity are counterbalanced by intensified capillary transport on the surface, so that the influence on the drying rate is considerably reduced. This explains why the plaster system results in a much quicker drying of the wall, but at the same time tends towards salt efflorescence in salt-affected walls due to its capillary activity.

A new drying characteristic value should describe the drying characteristic of a construction material that depend on its own material transport properties (e.g. porosity), the environmental drying ratios and the flow conditions on the evaporation surface (Figure 5). A draft standard is currently being drawn up. The aim is to anchor the drying characteristic value in the DIN or EN standard.

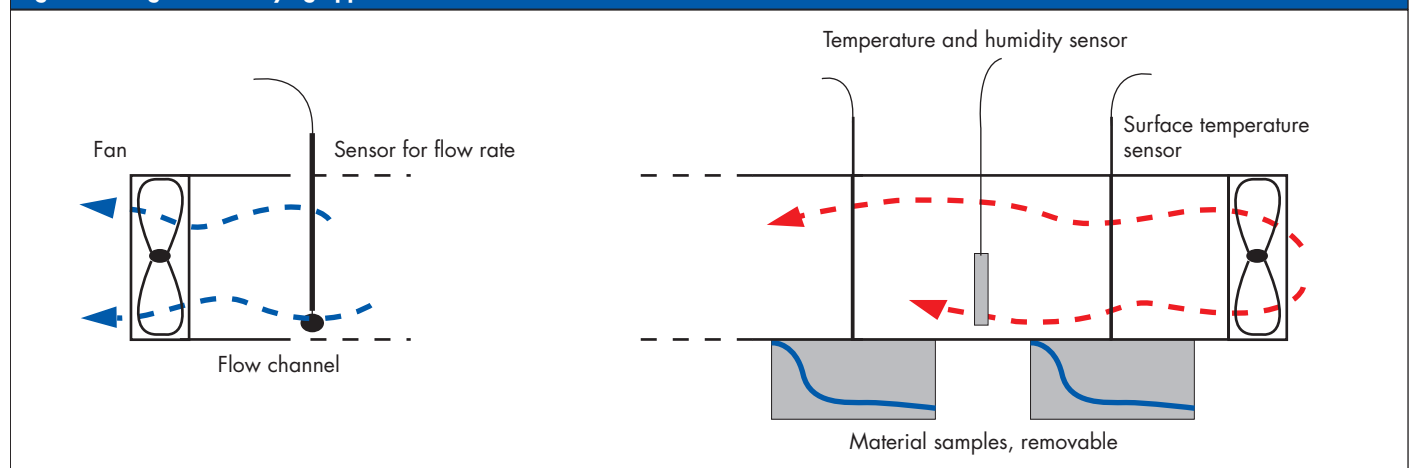
Figure 5 shows a diagram of a measuring system developed at Dresden University.

Figure 4: Microscopic photograph of a typical indoor mould: Cladosporium cladosporioides



This enables the drying process to be determined under constant framework conditions.

Figure 5: Diagram of a drying apparatus



► Materials database

Using the MASEA materials database

The database is freely accessible online at www.masea-ensan.de. The construction materials are divided into different categories. Each category is allocated the relevant construction materials. For example, calcium silicates are listed under the category "insulation materials" (Figure 7).

System prerequisites

- Internet connection on a PC or Mac
- Browser such as Internet Explorer, Firefox, Opera
- for planning tool applications, e.g. WUFI®, DELPHIN®, EPASS HELENA®

Application examples

Knowledge of hygrothermic characteristic values is important for the installation of interior insulation, which can be very challenging from a building physics point of view, and which must be installed with expert knowledge. For example, a capillary active inside insulation system can be used with which condensation accumulates at a defined spot and is then quickly transferred to the room through the capillary properties of the material. The advantage of this variant is the improved drying properties of the wall. Thus moisture that gets into the structure, e.g. by driving rain, can dry out on the inside. However, the condensation may not exceed a certain limit value. Hygrothermic assessment of a capillary active interior insulation system requires that the capillary moisture transport is taken into account.

Database for planning tools

The materials database is available online. On the one hand, this should enable updating and control of the database by industry and research, on the other hand this instrument can provide a broad calculation basis for energy-oriented planning software such as WUFI®, DELPHIN® and EPASS

HELENA® as well as other software tools. Software tools for the energy-oriented refurbishment of buildings can be used to quantify the influence of measures on the hygrothermic behaviour of buildings and to assess the risk of damage. They are well tested these days – their limits lie in the lack of exact material characteristic values. Because every prognosis and calculation is only as good as the knowledge of the available materials.

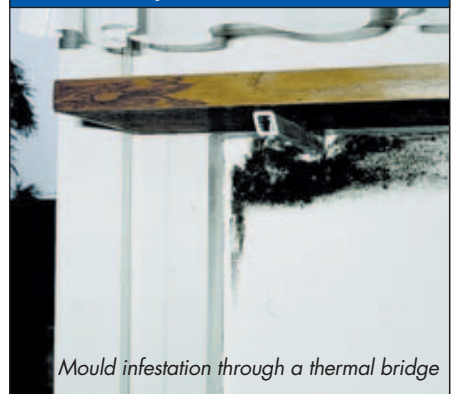
The objective and areas of application of the programmes vary greatly. They are briefly characterised here on the basis of WUFI®, DELPHIN® and EPASS HELENA®. The current versions of the above programmes access the online material database MASEA.

WUFI®: The calculation programme WUFI® demonstrates the hygrothermic behaviour of a building component on the basis of given climate developments. The calculation results are shown in a film-like sequence of the moisture and temperature profiles.

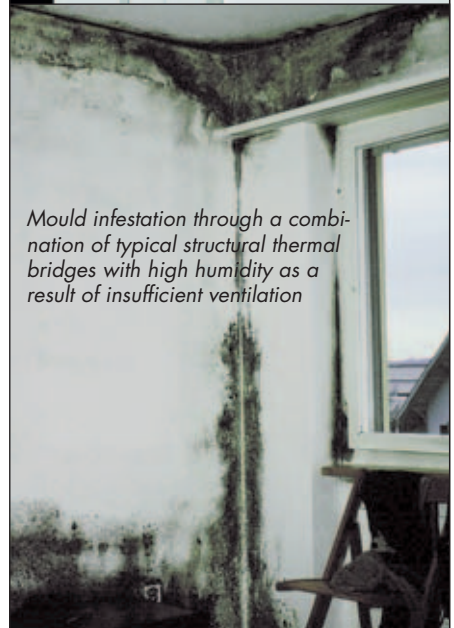
DELPHIN®: The numeric simulation programme is used for mathematical investigation of the heat, moisture, air and salt transport in building components. The theory on which the programme is based is derived from thermodynamic principles, which describe the transport process and phase transitions.

EPASS HELENA®: This planning tool is an expert software for the calculation of the energy interrelationships of buildings. The programme enables the different temperature zones of a building to be measured. Detailed presentation of the system engineering is another advantage.

Figure 6: Mould infestation through moisture accumulation on the surface and in the building component



Mould infestation through a thermal bridge



Mould infestation through a combination of typical structural thermal bridges with high humidity as a result of insufficient ventilation

Moisture atlas

The widely used thermal bridge catalogues offer an abundance of thermal solutions, but do not take the hygric situation into account, or deal with it superficially, which can lead to misjudgements. The moisture atlas can help by providing a compilation of usual structural, one-dimensional standard wall constructions for exterior and interior insulation. With the help of modern calculation and simulation tools (DELPHIN®, COND®), solutions are proposed for structures that present difficulties from a hygrothermal point of view, and suitable refurbishment methods are presented for old and new buildings. The calculations have been made for a test reference climate, a DIN and EN compliant block climate and can thus be used to evaluate the behaviour of a structure. Besides documentation and annotation of results, special reference is made to high-risk structures. The latter require individual analysis of planned thermal refurbishment measures. Along the same lines as a thermal bridge catalogue, the moisture atlas is addressed to all architects, construction engineers, structural damage assessors and building conservationists working in the construction industry and is expected to be published in book form with accompanying CD-ROM at the beginning of 2008.

Figure 7: Building physics characteristic values (categories: insulation materials; boards)

MASEA material data sheet · Calcium silicate				
Characteristic value	Symbol	Unit	Value	Reference
Bulk density	ρ	[kg/m ³]	270	[Plagge, R.: current]
Specific thermal storage capacity	c_p	[J/kg K]	1200	[Plagge, R.: current]
Thermal conductivity	λ_r	[W/m K]	0.07	
Diffusion resistance coefficient (dry) 23°C – 3/50%	μ	[-]	3.8	
Sorption	$u_{(80)}$	[kg/m ³]	20	
Free water saturation	$u_{(f)}$	[kg/m ³]	790	
Water absorption coefficient	w_w	[kg/√h]	67	
Open porosity	ϕ	[Vol – %]	90	

The data sheet contains the "building physics characteristic values". In addition, most construction materials are described in detail with illustrations, a listing of features and explanatory notes as well as the presentation of important properties in diagram form. The data can be used online via an xml interface for all current software products. The data sheets can also be saved as pdf files and printed. This enables construction material data to be collected and stored as it suits the individual.



► Conclusion

The current provisions for energy saving and climate-related moisture protection have to be observed with the refurbishment of old buildings. Usually however, economic constraints or the requirements relating to the conservation of listed buildings place restrictions on what can be done in terms of construction engineering and a workable compromise has to be found between thermal insulation and living comfort on the one hand and the available budget or preserving historical facades on the other.

The contents of the material data collection for the energy-oriented refurbishment of old buildings provides an ideal basis for answering questions relating building physics or making economic efficiency calculations. This enables the actual state of buildings to be recorded for energy-saving assessment. Planning errors caused by incorrect estimates of material behaviour could be avoided in the future. The material data collection will become an important tool for everyone involved in the refurbishment of old buildings. Making the data accessible on the Internet will accelerate the process.

► Outlook

The materials database will be continuously expanded and updated to include current and new construction materials. For this reason protected online access will be provided both for construction material manufacturers and research institutions. The database currently contains 475 materials. Companies have the opportunity to supply data on material characteristic values via the institutes responsible for the project who are acting as intermediaries. Emphasis is being placed on the inclusion in the data collection of materials that are relevant for the refurbishment of old buildings. This application will enable the further development and maintenance of the database.

► PROJECT ADDRESSES

- Fraunhofer Institut für Bauphysik (IBP)
Institutsteil Holzkirchen
Dr. Cornelia Fitz
Fraunhoferstraße 10
D-83626 Valley
- TU Dresden Institut für Bauklimatik
Prof. Dr. Peter Häupl
Dr. Rudolf Plagge
Ulrich Ruisinger
Zellescherweg 17 d
D-01062 Dresden
- Zentrum für Umweltbewusstes Bauen e.V. (ZUB)
Sven Klauß
Gottschalkstraße 28 a
D-34127 Kassel

► ADDITIONAL INFORMATION

Literature

- Fitz, C. (Projektleiter); Klauß, S.; Krus, M. u.a.: Materialdatensammlung für die energetische Altbauanierung. Abschlussbericht. Fraunhofer Institut für Bauphysik, Stuttgart (Auftragnehmer; Hrsg.); Bundesministerium für Wirtschaft und Technologie, Bonn (Auftraggeber; Förderer) April 2007. 119 S., IBP-Bericht HTB-07/2007
- Scheffler, G.; Plagge, R.: Bestimmung des Trocknungsverhaltens von Baustoffen unter definierten Randbedingungen. In: Bauphysik. Jg. 27 (2005), H. 6, S. 323-330
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Images

- Fig. 1: Dr. Burkhard Schulze Darup, Architect
Small photo left: Fraunhofer IBP
- Fig. 3: Franziska Herborn, Architect
- Fig. 4: Fraunhofer IBP
- Fig. 5: University of Dresden
- Fig. 6: EMPA-Akademie: Building envelope, IRB Verlag, Stuttgart, 2000

Service

- Additional information in German is available online from BINE at www.bine.info (Service/InfoPlus)

PROJECT ORGANISATION

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Markus Kratz
D-52425 Jülich

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■ Editor

Franziska Herborn, Micaela Münter

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Informationsdienst

FIZ Karlsruhe, Büro Bonn
Kaiserstraße 185 – 197
D-53113 Bonn

Tel.: 0228 92379-0
Fax: 0228 92379-29

bine@fiz-karlsruhe.de
www.bine.info