

Measurement and Analysis of Hygro-thermal Material Parameters of Old and New Building Materials for Software Tools in Building Construction

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Background

Especially for buildings, constructed before 1975, the energy saving potential is the greatest among buildings and cover approximately 80 % of the German buildings. Improvements in the area of room climate (heating, ventilation, cooling) and building provision (application of an insulation) result in large energy saving. Since 1. February 2001, the renovation of buildings is controlled by the German EnEv 2001 regulations and DIN 4108-2, the heat insulation has a higher importance in building modernisation, than moisture protection. Often this lead to serious moisture problems, coming from e.g. moisture condensation and mould growth, identifying errors during the design and construction phase of the modernisation. Building physical calculation and simulation software e.g. EMPASS-HELENA, WUFI, DELPHIN, COND, ESTHER or AGROS, used to judge the planned constructions, base on the quality of the material property input. Since no, or little data are available for former building materials, the simulations often fail at predictions. The most older building materials are not produced at all and their moisture related properties are not known. More over, the building materials have not been manufactured according to actual requirements and show a large variation. Nevertheless, the hygro-thermal material properties are required to analyse the energetic and hygric behaviour of the buildings.

Project

The aim of the German research project „MASEA“, funded by the BMWF is: 1. to analyse a large number of old and ancient building materials of the old building stock and 2. to collect the hygric and thermal characteristics together to a database. The national project is a cooperation between the IBP-Holzkirchen, the ZUB-Kassel and the IBK-Dresden.

Modernisation and renovation of older buildings demand the combined use of former building materials with actual materials. This require the insertion of actual and new building materials

into the database for old building materials. *You as producer of building materials*, we like to invite you, to take part in the development of the innovative EnSan-material property database and submit your building products to the Technical University Dresden, or employed research institutes. Having your assistance, a complete hygro-thermal material property database and modern simulation technology, the evaluation of the hygic load and the energy saving of a construction can be done. It is also possible to account for different climatic conditions and various usage.

The database is supported by three industrial organisations, *GDI*, *VDZ* and *Bundesverband Glas im Bau*. The organisations and *DENA* with their „Energy Licence Initiative Germany“ are developing software for building modernization of older houses. The improved database will also support a first extension advice for craft in renovation of older buildings.

The project at the TU-Dresden uses multi-technologies as design tools e.g. special laboratory equipment and measurements, a functional material characterisation, verified parameters and material functions. The generation of the database is innovative. The delivery for EnSan-simulation tools is leading to new or improved **integrated building constructions**.

General aims of the project

Improvement of prediction of EnSan-simulation tools by the development of an accessible material property database, as a base for the energetic building simulation and hygro-thermal calculations on building constructive details. These aims will be received by:

1. Measurement of characteristic material properties of old and new building materials, using special measurement techniques and validated methods;
2. Functional characterization and physical interpretation of measured material data and verification of coupled functions by dynamic experiments;
3. Development of a hygro-thermal material property database of old and new building materials to support building physical software;
4. Application of simulation tools to analyse and evaluate the energetic and hygro-thermal performance, reliability and damage risk of building constructions and the quality of craftsmen work.

Working program

Workpackage 1: Material selection. The choice of old building materials are concluded by a preferential list from the EnSan-Software producers, the building conservation and building practice. The actual material list consist of seven material groups: 1. building masonry, 2. plaster and mortar, interior cover and boards, 4. insulation and loose goods, 5. paint and coatings, 6. foils, 7. area of roof. A more detailed description can be found at the end of this presentation.

The material selection of actual building materials is done by the material producer himself. A manufacturer deliver his materials to the University Dresden and order via University/Producer contract the hygro-thermal material characterization in the frame of the MASEA-project. In this contract, the work of the University is defined, as e.g. measurement, characterisation, database entry and mandatory of EnSan-software.

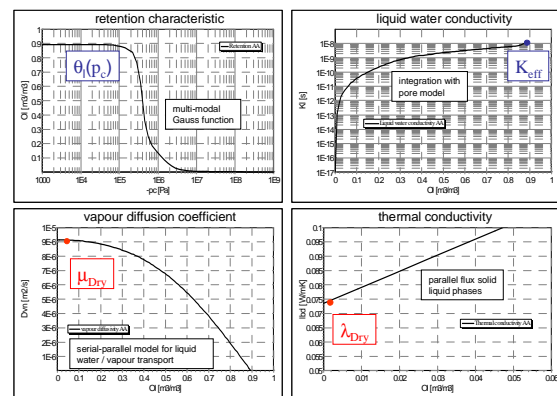


Work package 2: Measurement of building materials. The old and new building materials are prepared for the measurement cycle of the IBK-laboratory. After sampling, assessment of dimensions and lateral sealing, the following relevant hygro-thermal properties are measured:

- *Basic properties:* matrix density, dry bulk density, total and open porosity
- *thermal properties*¹: moisture dependent heat conductance and heat capacitance
- *hygric properties:* moisture storage in the hygroscopic and the over-hygroscopic range (sorption isotherm and water retention), water vapour diffusion coefficient, moisture conductivity, water uptake coefficient, drying coefficient.



Work package 3: Determination of characteristic material functions. The measured material properties have to be prepared for the direct use in simulation models. Computer codes require differential and integral functions and not single numbers. The using a physical material model, the properties functions, where the water retention characteristic, the liquid water conductivity, the water vapour diffusion coefficient and the heat conductance are given as functions.



To guarantee reliable results, the measurements in the laboratory and their functional characterisation are controlled. The material characterisation, found by the functional description, is used to simulate dynamic water uptake and evaporation experiments. A physical-based simulation code is afterwards applied to interpret the results and to adjust and verify the material characterisation.

Work package 4: Development of a material property database.

The material properties and the hygro-functions of the old and new building materials are stored in a relational database system. Within the database the material functions can be visualized in clear structure to support material selection. The structure of the database is organized, to implement future additional and updates. An implementation of supplementary material properties, more important for the organization of the renovation and an integrated performance analysis as well, is possible.

| No. | Source | English Name | rho |
|-----|------------|-----------------|------------|
| 55 | TU Dresden | PIR-Foam | 15 kg/m³ |
| 56 | TU Dresden | PS-FoamExpanded | 30 kg/m³ |
| 57 | TU Dresden | PS-FoamExpanded | 20 kg/m³ |
| 58 | TU Dresden | MaxcellVool | 30 kg/m³ |
| 59 | TU Dresden | IsaFlocc | 65 kg/m³ |
| 60 | TU Dresden | FenakelHyFoam | 14 kg/m³ |
| 61 | TU Dresden | Cook | 290 kg/m³ |
| 62 | TU Dresden | GypsumPlaster | 1170 kg/m³ |
| 63 | TU Dresden | GypsumBoard | 1000 kg/m³ |

The data, required for Insane-simulations, can be linked to the respective simulation programs, since a defined connection will become available. Thus architects, building engineers and craftsmen receive a software planing tool, much better than before, to quantify the hygro-thermal behaviour of buildings, to analyse the performance of building constructions and to prevent damages at building constructive details.

1. The thermal properties of building material are measured at the laboratory of our scientific partner.

Work package 5: Application of multi-technologies as design tools. If you as an industrial partner attend the project, you will have the following advantages:

Beside the hygro-thermal characterisation of your building products and the entrance into the database for EnSan-simulation software, we can solve a number of problems of your interest. Examples are:

- energetic and hygric analysis of building constructive details at actual building constructions (e.g. Church of Our Lady Dresden),
- Analysis of reliability of your products,
- Estimation of the damage risk of your product, its combination with old building materials from an old construction from the database,
- comparison of building materials from a material producer, manufactured at different factories and control of produced quality,
- combination of different building materials, to receive the desired material property,
- integrated building construction by application of modern laboratory technologies in combination with simulation tools,
- Support of the craft by analysing different erection of the craftsmen work,
- application of a climatic chamber system in combination with modern measurement techniques to analyse building materials and building constructive details at free eligible climatic conditions (test of applicability in different countries and extreme use).



In the frame of the material investigations the building material producers have the possibility to clarify specific questions about their product.

The attending industrial partners at the moment of the start of the project are listed in the table.

| producer of building materials | building materials |
|----------------------------------|--|
| Calsitherm Silikatbaustoffe GmbH | Calsitherm Klimaplatte |
| HUFGARD-TUBAG GmbH & Co | Klimaputz (KP1), Klimaputz Maschinenputz (KMP1), Trasskalk-Maschinenleichtputz (TKM-L 410), Trass-Mineraldämmputz (TMD 02), Sanierhaft-Glättoputz (SHG), Trasskalk-Feinputz (TKF) Silikatfarbe und Kalkfarbe auf Feinputz |
| REMMERS Baustofftechnik GmbH | Aisit Schimmel Sanierputz (ReAS), Sanierputz leicht (Re SPL) |
| Haniel GmbH | Fermacell, Multipor, Porenbeton, Kalksandstein |

Table: General overview over the MASEA-materials and attending producers of building materials. Multiple designations of building materials for a material branch are in any case disired. Missing materials in the can be supplemented in the primary list.

| MASEA-materials | project partner |
|--------------------------------------|---|
| Mauerwerksbildner | |
| clinker | |
| solid brick | |
| vertically perforated brick | |
| sand (lime) stone brick | Haniel GmbH |
| aerated concrete | Haniel GmbH |
| floating stone | |
| nogging | |
| natural sandstone | |
| broken-brick concrete masonry | |
| slag concrete masonry | |
| tamped concrete | |
| tuffstones | |
| plaster and mortar | |
| lime | HUFGARD-TUBAG |
| lime cement | Hufgard-TUBAG, REMMERS Baustofftechnik GmbH |
| cement | Hufgard-TUBAG, REMMERS Baustofftechnik GmbH |
| synthetic plaster | |
| mineral insulation plaster | Hufgard-TUBAG |
| interior cover and boards | |
| gypsum floorboard | |
| brick board | |
| reed | |
| plastered wood cement particle board | |
| calciumsilicate | Calsitherm Silikatbaustoffe GmbH |
| gypsum fibre board | Haniel GmbH |
| insulation and loose goods | |
| cork | |
| fibre board | |
| diatomite | |
| blast furnace slag | |
| paint and coatings | |
| silicate colour on final plaster | |
| lime colour on final plaster | |
| foils | |
| grease paper | |
| roofing felt | |
| area of roof | |
| ancient timber | |
| pine | |
| spruce | |
| roof tile | |
| reed tile | |
| shingle | |
| slate | |

If we can waken your interest, please contact us with your request and, if occasion arises, your participation request. Contact persons in our institute are:

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Missing building materials in the MASEA-building material list:

Please submit us more information and an offer on material characterisation in the frame of the MASEA-project.

| | |
|-------------|--|
| name: | |
| company: | |
| department: | |
| address: | |
| town: | |
| country: | |
| telephone: | |
| fax: | |
| e-mail: | |