Internal insulation

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Jens Engel, REMMERS
Dagmar Exner, EURAC

The research leading to these results has received funding from the European Community’s Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 260162

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Internal insulation

Ayman Bishara
Why insulation?

- Energy saving
- Environmental protection, CO2-reduction
- Reduction of cost of operation
How does an interior insulation system work?

Operation of diffusion-tight interior insulation:
- No moisture accumulation,
  no condensation,
  hardly steam flow,
  low drying potential

Operation of diffusion open and capillary-active interior insulation:
- Moisture accumulation
  - steam flow
  - water transport
  - high drying potential

Course of Temperature and Vapor pressure
Different materials for internal insulation:

- Mineral fiber
- Perlite
- Foam glass
- Wood fiber
- Mineral foam
- Calcium silicate
- Cellulose
- PUR
Case studies

Ayman Bishara
Dagmar Exner
Classicism building in Potsdam
Wilhelminian building in Dresden
Baroque building in Görlitz
Renaissance building in Freiberg
Objective: additional to evaluation of the energy efficiency, analysis and evaluation of planned insulation systems with focus on possible condensation and critical moisture contents in construction and the risk of mold growth
### Which insulation materials are used?

<table>
<thead>
<tr>
<th>Potsdam</th>
<th>Dresden</th>
<th>Freiberg</th>
<th>Görlitz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loam cork kieselguhr</td>
<td>IQ-Therm</td>
<td>Tec-Tem</td>
<td>Calciumsilicate</td>
</tr>
</tbody>
</table>

- Loam cork $\lambda = 0.08 \text{ W/mK}$
- IQ-Therm $\lambda = 0.028 \text{ W/mK}$
- Tec-Tem $\lambda = 0.045 \text{ W/mK}$
- Calciumsilicate $\lambda = 0.065 \text{ W/mK}$
CS6 - Procedure for developing and planning of a suitable interior insulation system
CS6 - Baroque building in Görlitz

Focus

- inside insulation facing to the street and EIFS facing to the backyard
- development and built of box-type windows with heat protection, glazing made of „solar glass“

Building before and after renovation
CS6 - Görlitz
planned solutions

North side, facing to the street

South side, facing to the street

• inside insulation facing to the street

U-value = 0.40-0.60 W/m²K

calcium silicate

thermal insulation plaster

calcium silicate
Kitchen on the 2nd floor, temperature and humidity of the indoor climate and humidity and temperature conditions in the wall, January
Kitchen on the 2nd floor, temperature and humidity of the indoor climate and humidity and temperature conditions in the wall.
Focus

- zero energy consumption without destroying the historic appearance of the building
- evaluate the energy reduction potential and economics to give guidance for future projects
- create attractive living space in the historic city center

Building before and after reconstruction
CS6 - Freiberg
planned solutions

- Facing to the street
- Fire wall
- Windows
- Roof
- Facing to the backyard
  - EIFS and internal wall insulation
CS6 - Freiberg – discussion of the results

Energy heat consumption

Annual heat consumption for floor heating of 4,140 kWh/a (19.7 kWh/m²a) plus 2,226 kWh/a for hot water.
CS6 - Classicism building in Potsdam

Focus

• analyze the internal insulation planned with a focus on possible condensation and critical moisture

• critical moisture content in wood construction and the risk of mold growth

• driving rain protection, hydrophobic impregnation

Building before and after reconstruction
CS6 - Classicism building in Potsdam

Schinkel magazine 3

timber-framed construction, inner wall
CS& - Potsdam – discussion of the results

not insulated  
60mm loam-cork insulation  
80mm loam-cork insulation

Range of relative humidity at the time of maximum moisture load (Delphin-simulation)

Wooden beam

15mm inner plaster  
240mm historic brick  
10mm mortar layer  
120mm clinker brick

94% rH  
96% rH
CS& - Potsdam – discussion of the results

Moisture content of the wooden beam [Vol%]

Critical boundary value

Technische Universität Dresden
EURAC research
Over hygroskopic moisture content in the construction [Vol%]

Time [a]
Adaptive hydrophobic impregnation

- functionality and durability of driving rain protection
- homogeneous penetration up to 15mm depth
- applicable on moist undergrounds → emulsions cream
- keeping drying potential
- unchanged optical impression after application
Moisture content of the wooden beam after hydrophobic impregnation [Vol%]

Critical boundary value

- West - Ausrichtung
- Ost - Ausrichtung

Moisture content [Vol%]

Time [a]

Jan 1850 1900 1950 2000 2050 2100 2150 Dez

Discussion of the results
CS6 - Wilhelminian building in Dresden

Focus

- construction details
- handling of wooden beam head
- suspended ceilings, F30 fire protection requirement
- evaluation of wall heating system

Building before and after renovation
Measurement Loschwitzer Straße
Temperature and relative humidity
Outer climate

rel. humidity [%]

Temperature [°C]

01.10. 1. year 01.10. 2. year 01.10. 3. year

Time
Measurement Loschwitzer Straße
Temperature and relative humidity
Inner climate

rel. humidity [%]

01.10. 1. year 01.10. 2. year 01.10. 3. year

Temperature [°C]

rel. Luftfeuchte Innenraum
Temperatur Innenraum
Temperature and relative humidity - wooden beam end
Relationship between Outer air temperature and indoor humidity
Project Loschwitzer Str. DD

CS6 - Dresden – discussion of the results
Evaluation of the temperature and relative humidity (boundary element)

daily averages for the evaluation is used

<table>
<thead>
<tr>
<th></th>
<th>1. year</th>
<th>2. year</th>
<th>3. year</th>
<th>...</th>
<th>7. year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of d, over the limit</td>
<td>39</td>
<td>12</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Maximum RH at &gt; 0°C</td>
<td>96,1</td>
<td>94,9</td>
<td>84,8</td>
<td>0,0</td>
<td>%</td>
</tr>
</tbody>
</table>
Simulation results of the wooden beam end under real climate condition

Temperature at the most critical day

Relative humidity at the most critical day

M(%) = 13.62 kg
Moisture progression - wooden beam

\[ M_{\text{Wood}} = 13.62 \text{ kg} \quad > \quad M_{\text{Wood, allowed}} = 20 \text{ kg} \quad (\text{measurement after 1 year of settling}) \]
Planning progress – use of building:

- Ideas competition to define the future utilization concept of the Weighhouse as a “House of Photography" -> published in May 2012, selection of 10 planners and start of competition phase: beginning of July, delivery of projects; November publication of decision -> besides utilization concept it was asked explicitly to exploit the energy potential of the building

- The winner will project and realize the refurbishment
CS1 - State of diagnosis pre-intervention

Analysis of architectural elements

- Precise measurement of stratigraphy of construction elements -> drawing of detail sections with correct dimensions
- **Analysis of material parameters** (from material samples) through TUD for the Delphin database
- Documentation of the building in the DIS database
Installation of internal insulation in one test room – actual state

Simulations in DELPHIN of two significant points:

- Floor (beam ends)
- Ceiling (beam ends)
- Comparison of 2 thicknesses: 5 and 8 cm with as-is-state
Installation of internal insulation in one test room – actual state

Simulations of three points in Delphin by TUD:

- Window prototype/window reveal
- Floor (beam ends)
- Ceiling (beam ends)

Comparison of 2 thicknesses: 5 and 8 cm

Calculation under unsteady state conditions (real climate of Bolzano)

Outer wall thickness = 60 cm, insulated with 8 cm IQ-therm, window reveal insulated with 3 cm IQ Therm.
Distance between window/finish to the outer edge: ≥ 12.6 cm

Temperature field, surface temperature [°C]. CVW 60 cm insulated with 8 cm IQ Therm, window reveal insulated with 3 cm IQ Therm.
Boundary conditions: Bolzano outdoor climate on January 10th

floor construction – first floor (room 20)

ceiling construction – first floor (room 18)
Simulation of beam ends floor (ceiling “portici”)
Comparison: relative humidity and temperature within the structure on a cold winter day (Winter 2\textsuperscript{nd}/3\textsuperscript{rd} year: 12\textsuperscript{th} January)
Installation of diffusion open interior insulation with capillary redistribution

- **Wooden beams in ceiling**: implementation of two different connections
- **Monitoring and comparison of both solutions**: wood moisture content, temperature and rel. humidity

**Version I: „interrupted” insulation**

- Interior insulation iQTherm 8 cm
- Near field temperature and rel. humidity + surface temperature
- Wood moisture content
- Airtightness layer (blue line): Interior plaster + wood composite (or wax paper)

**Version II: „continued” insulation**

- Interior insulation iQTherm 8 cm
- Airtightness layer (blue line): Interior plaster + wood composite (or wax paper)
- Wooden beam
- Airtightness layer (blue line): Interior plaster
Summary of the research results

Ayman Bishara
## Criteria for comparison of different internal insulation systems

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
<td>loam cork</td>
<td>IQ-Therm</td>
<td>Tec-Tem</td>
<td>Calciumsilicate</td>
</tr>
<tr>
<td><strong>Appearance</strong></td>
<td><img src="image1" alt="loam cork" /></td>
<td><img src="image2" alt="IQ-Therm" /></td>
<td><img src="image3" alt="Tec-Tem" /></td>
<td><img src="image4" alt="Calciumsilicate" /></td>
</tr>
<tr>
<td><strong>Insulation effect</strong></td>
<td>$\lambda = 0.08$ W/mK</td>
<td>$\lambda = 0.031$ W/mK</td>
<td>$\lambda = 0.045$ W/mK</td>
<td>$\lambda = 0.065$ W/mK</td>
</tr>
<tr>
<td><strong>Material and Form</strong></td>
<td>frame, plaster</td>
<td>board, plaster</td>
<td>board, plaster</td>
<td>board, plaster</td>
</tr>
<tr>
<td><strong>Capillary active</strong></td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td><strong>Moisture regulation</strong></td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td><strong>Natural material</strong></td>
<td>++</td>
<td>-</td>
<td>+ / -</td>
<td>+ / -</td>
</tr>
<tr>
<td><strong>Fire protection</strong></td>
<td>-</td>
<td>-</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td><strong>Soundproofing</strong></td>
<td>++</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Sustainable</strong></td>
<td>++</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Workmanship</strong></td>
<td>-</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Costs</strong></td>
<td>100 €/m²</td>
<td>45 €/m²</td>
<td>45 €/m²</td>
<td>75 €/m²</td>
</tr>
</tbody>
</table>
Compatibility of energy saving potentials

Potential savings of final energy consumption costs

I
2
1
3
4a
4b
4c
4d
4e
5a
5c
5c
5c
6
7

III

30% 20% 10% 0% ~ +

© Professur für Bauphysik / Professur Denkmalpflege und Entwerfen (TU Dresden)
Summary

Positive effects of interior insulation

• Energy saving and CO₂ –reduction
  → contribution to the environmental protection

• Protection against condensate and mould growth
  → prevention of damaged e.g. after window exchange

• Improvement of thermal comfort
  → increasing value of rehabilitated buildings

• Keeping brick masonry constructions as they are

• Fast heating for temporary used rooms
Advantages of capillary active interior insulation

(*multi functional properties vary between different building materials*)

- Moisture regulation of construction
- Keeping healthy room climate
- Diffusion open construction
- Keeping drying potential
- Reduction of freezing damage probability
Guidance for future projects

Ayman Bishara
Planning guide for the application of interior insulation

**Interior insulation:** capillary active interior insulation systems function requires: the moisture management has to be integrated into the planning phase

**Hygrothermal simulation:** allows the thermal & hygric evaluation of interior insulation constructions under real climate conditions

**Usage of real climate conditions:** evaluation of construction under simplified conditions (e.g. national standard building code conditions) may cause damages

**Evaluation of complex construction details:** complex construction details require numerical computer simulation tools (e.g. computation of thermal bridges)

**Driving rain protection of the outdoor wall:** avoid moisture problems (e.g. frost damages of insulated wall, increases of drying of constructions)

**Air tightness/convection:** avoid moisture problems (e.g. condensation damages, moisture accumulation in wall details)
Develop of new material

Jens Engel
Aim

- Optimisation of the filling gel
- Development of a new capillary active render
- Further development of a clay based, reversible adhesive
- Development of insulation boards based on different insulation materials related to
  - improved fire resistance
  - improved thermal conductivity
- Demonstration of the interior insulation system at several historic buildings / Practice tests
Optimisation of the Filling Gel

- Different types of the filling gel have been developed and investigated in terms of
  - pourability,
  - pot life,
  - capillary absorption,
  - capillary condensation,
  - diffusion coefficient,
  - microstructure
- For the production of the boards one suitable filling-gel has been defined (improvement compared to the initial formulation)
Development of a New Capillary Active Render

- New render (thickness 5 mm) for use instead of the plaster (thickness 10 to 15 mm)
  - easier to process (especially for painters)
  - higher capillary moisture transport
  - lower water vapour sorption,
- Development is completed, filler has been put on the market (iQ-Top SP)
Further Development of a Clay Based, Reversible Adhesive

Dipl.-Ing. Jens Engel
Development of insulation boards based on different insulation materials than PU foam.

- related to
  - improved fire resistance
  - improved thermal conductivity

- Two different materials have been tested
  - Foamglass-boards
  - Aerogel (ciliceous aerogel produced in a glassfibre fleece with a thickness of 10 mm)
Foam glass-boards

- Advantages: not flammable and very stiff (noise protection)
- Problem:
  - the foam glass could not be produced with the already existing production line because the process produced granular glass which has negative effects on the automation and conveyor technology
- Nevertheless foam glass was used in one of the demonstration projects for reduction of the longitudinal sound transfer of the insulated wall at the connection point to a flat partition wall
Foam glass-boards

ANSCHLUSS F90 WAND AN AUSSENWAND, GRUNDRISS

AR_DT_0_XX_002
Aerogel-Boards

- Aerogel (siliceous aerogel produced in a glass fibre fleece with a thickness of 10 mm)
- Prototypes have been produced by lamination of several glass fibre fleeces on each other
- Application tests have been carried out in the remmers testing facility
- Advantage:
  - Thermal conductivity $\lambda \leq 0.16$ W/mK
- Problems:
  - punching the necessary holes
  - price (~ 2000,- €/m³)
iQ-Therm – Installation Decoupling
iQ-Therm – Installation
Level Out The Surface
iQ-Therm - Installation
Preparing The Machining Area
iQ-Therm – Installation
Bonding
iQ-Therm - Installation
Combinated Bonding Technique
iQ-Therm - Installation
Avoidance of Crossing Gaps
iQ-Therm – Installation
Cutting
iQ-Therm - Installation
Cutting
iQ-Therm - Installation
Fixing of the Boards
iQ-Therm - Installation
Wedges Insulation
iQ-Therm - Installation
Sockets
iQ-Therm – Installation
Sockets
iQ-Therm – Installation
sockets
iQ-Therm - Installation
Fixture Tubes
iQ-Therm - Installation
Elimination of Faults
iQ-Therm - Installation
Fixing of Protection Rails With IQ-Fix
iQ-Therm - Installation
Plastering iQ-Top, First Layer
iQ-Therm - Installation
iQ-Tex (Glass Fibres Fabric)
iQ-Therm – Installation
Additional Reinforcement at Window Corners
iQ-Therm - Installation
Plastering, Final Layer
iQ-Therm - Installation
iQ-Top/iQ-Top SP, Final Layer
iQ-Therm - Installation
Coating With Mineral Paint
System Products

- iQ-Fix / Lehmkleber
- iQ-Therm L15/30/50/80
- iQ-Top / iQ-Top LM / iQ-Top SP
- iQ-Tex
- iQ-Fill / iQ-Fill Q4
- iQ-Paint / iQ-Paint ST / iQ-Paint IR
### Complementary products

<table>
<thead>
<tr>
<th>Product</th>
<th>Art.-Nr.</th>
<th>Packaging</th>
<th>Properties</th>
<th>Application rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressed Band 15/5-10</td>
<td>4272</td>
<td>10 m in a carton</td>
<td>The band is activated by pulling off the foil, air tight, (corresponds to the requirements of DIN 4107-7)</td>
<td>approx. 1.0 m/m</td>
</tr>
<tr>
<td>Partition Wall Strips</td>
<td>4258</td>
<td>12 rolls in a carton</td>
<td>3 mm thick, 75 mm wide, roll 30 m long</td>
<td>approx. 1.0 m/m</td>
</tr>
<tr>
<td>All-Purpose Dowels 50</td>
<td>4284</td>
<td>50 dowels in a carton</td>
<td>Load bearing capacity: 15 kg, For fast, cost effective fixing with normal tools</td>
<td>as required</td>
</tr>
<tr>
<td>Mounting Cylinder</td>
<td>4257</td>
<td>1 cylinder</td>
<td>Lambda = 0.04 W/(m*K), highly compression resistant, fast, precise execution, subsequent fixings without problems. D = 125 mm, L = 540 mm</td>
<td>as required</td>
</tr>
<tr>
<td>Shaping Tool</td>
<td>4255</td>
<td>1 tool set</td>
<td>Contents: Cutting table D = 125 mm, cutting guide bell with handle, adjusting ring with pinion spanner, carrier for cutting depths up to 200 mm</td>
<td>N/A</td>
</tr>
</tbody>
</table>
iQ-Therm – Demonstration Projects

REFERENCES

Villa am Mühlenort, Greifswald

Bürgerhaus, Staßfurt

Bankhaus Seeliger, Wolfenbüttel

Alte Jugendstil-Villa, Recklinghausen

more? www.remmers.com
D5.1 - Demonstration

- Guideline for installation
- User Manual
  - How to place the Wardrobe
  - How to fix pictures, cupboards, etc.
  - What paint-systems should be used
  - What about wallpapers
- FAQs
- Reference database
- Certifications and approvals
Prüfzeugnisse / Berichte / Zusatzinformationen

- Umwelt-Produktdeklaration
- Prüfbericht FIW, München
- Klassifizierung Brandverhaltens nach DIN EN 13501-1-MPA Braunschweig
- Prüfung Brandverhalten DIN EN ISO 11925-2
- DIBt Allgemeine bauprüfliche Zulassung
- Prüfzeugnis_Brandverhalten DIN 41021_MPA Braunschweig
- Untersuchungsbericht_Baustoffklasse DIN 41021_MPA Braunschweig
- Untersuchungsbericht_DIN EN ISO 11925-2_MPA Braunschweig
- Allgemeines bauaufsichtliches Prüfzeugnis - MPA Braunschweig
- Klassifizierung Brandverhalten EN 13501-1 - FIW München
- Brandverhalten incl. Oberputz iQ-Top SP - MPA Braunschweig
- Brandverhalten incl. Oberputz iQ-Top SLS - MPA Braunschweig
Conclusion
Energetic upgrade of historic building construction requires detailed knowledge in various fields

- building materials
- construction details
- real climate conditions
- hygrothermal simulation tools

→ A special education is required for an adequate refurbishment
→ New fields of education for architects, engineers, handcraft:

  _ university level (TUD, TU..) 
  _ graduation level (WTA, 3ecult.)