Test houses with capillary active interior thermal insulation

- Gründerzeithaus Dresden
- Umgebindehaus Ebersbach
- Fachwerkhaus Edemissen
- Bahnmeisterstraße Senftenberg
- Herrenschießhaus Nürnberg
Principles of the capillary active insulation

- Moisture condenses on the cold side
- Open for diffusion capillary active insulation
- Capillary forces brings back the condensed moisture

Functions:
- Moisture protection
- High capillary activity
- Thermal protection
Material development
Through collaboration between
Manufacturer Experiments and Simulations

European Union Project INSUMAT

Calcium-Silicate types
- Calcium-Silikat AA (initial product)
- Calcium-Silikat V62
- Calcium-Silikat T7-2
- Calcium-Silikat T7-14
- Calcium-Silikat T8-6 (End product)
- Calcium-Silikat T8-12
- Calcium-Silikat T9-13
- Calcium-Silikat T11-12
Solid phase matrix of calcium silicate

Components: Calcium oxide, Silica oxide, Cellulose, Wasser

Xonolite - masive structure
Tobermorite - needle like form

Desorption-Isotherms (23°C)
Characteristics of calcium-silicate AA

Pore volume distribution
- Logarithmic normal pore volume

Sorption isotherm
- Multimodal Gauss-Function

Moisture retention curve
- Multimodal Gauss-Function

Moisture conductivity
- Integration with a pore model

Diffusion coefficient
- Series-parallel model for vapor and liquid phases

Thermal conductivity
- Moisture and heat transport
Optimisation of calcium-silicate AA

Pore volume distribution

Sorption isotherme

Water retention curve

Saugspannungskurve

Flüssigwasserleitfähigkeit

Dampfdiffusionskoeffizient

Wärmeleitfähigkeit
Moisture content distribution depends on the type of calcium silicate

Clinker - Brick wall structure with an interior insulation system of Calciumsilicate simulation with stationary conditions (DIN 4108) for 60 days - *outside*: $T= -10^\circ C$, $RH= 80\%$ *inside*: $T= 20^\circ C$, $RH= 60\%$

Comparison of different Calciumsilicate materials of Calsitherm moisture profile versus structure after 60 days

- Clinker
- (1d-calculations)
- Brick
- Plaster
- Mortar
- CaSi

Good Connection between insulation and old structure:
- CalciumSilicate T8-6
- CalciumSilicate T8-12
- CalciumSilicate T9-13
- CalciumSilicate T11-12
Dresden: Renovation

- Indoor insulation with calcium silicate plates
- Weather station
Dresden: Climate data (12/96 - 6/01)

Temperature

Radiation

Air humidity

Verical rain
Dresden: indoor clima

Temperature indoor

RH indoor

12/96 - 06/01
Dresden: Measuring points

Wall cross section and places of measuring points on the ground floor
Dresden: measured and calculated

Temperature
cold side insulation

Temperature
inner surface

Heat flux on
inner surface

12/96 - 06/01
Gründerzeit-House in Dresden

moisture behind the inside insulation

3cm Kalziumsilikat - 1cm Kleber - 1.5cm Innenputz - 43.5cm Mauerwerk - 15cm Sandstein


- calculated
- measured

- Capillary active inside insulation - calciuimsilicate
Gründerzeit-House in Dresden

Moisture field within the structure 1999 to 2004

Moisture content in Vol%
Gründerzeit-House in Dresden

Moisture field within the structure 1999 to 2004

- Inner condensation
- Driving rain
- Sandstone
- Brick wall
- Capillar not active inside insulation
Nürnberg: Revovation

- Interior insulation
- Calcium silicate plates
Nürnberg: after renovation

Measuring points 2 and 1
Nürnberg: Measured and calculated

Relative humidity on cold side of insulation

Relative Luftfeuchte in %

Zeit in Tagen

11/01 - 04/02
Sapporo: measured and calculated

Comparison of measurements and calculations of model wall in Sapporo (Period 1-5)

Time in [d]

WatCont in [Vol%]

Lehmschicht 1  Lehmschicht 2  Kalkputz

Messung  Rechnung
Rehabilitation of a straw loam house (East Saxony)
Comparing wood MC on 13 mm depth

Simulated 2-D and measured in wood moisture distribution
2-D temperature distribution and placement of sensors
MC in the middle of framework without capillary conductivity (method ISO 13788)
MC in the middle of framework with real moisture conductivity

Loam plaster with built in moisture

Straw loam filling

Inside insulation with interstitial condensation
Total amount of condensation vs time with and without capillary conductivity

![Graph showing condensation over time with and without capillary conductivity](image)
Dresden: reconstruction of Our Lady Church

Outer sandstone cupola

Inner sandstone cupola

Glasswork

Spiral stairway

Indoor room of the cupola

\[ T_i = 20^\circ C, \text{r.h.} = 65\% \]
Temperature vs ventilation rate

Ventilation rate

- n = 1.00/h
- n = 0.50/h
- n = 0.25/h

Zeit (a)


(Ende: 31. Dez.)
Moisture in outer cupola wall for $n = 0.5 \text{ 1/h}$
Effect of climate plaster on RH in the cupola

Ventilation rate $n = 0.5$/h

--- without climate plaster

--- with climate plaster

Zeit (a)

(Beginn: 1. Jan.)
(Ende: 31. Dez.)
MC distribution in cupola wall, effects of rain (left) and climate plaster (right)
„Church of Our Lady“
Dresden,
Germany,
after the rebuilding

December 2005
Rijksmuseum Amsterdam

Built by Pierre H.J. Cuypers in 1885
Rain flow density in Amsterdam (driving rain on the westside)
Course of relative humidity on inner surface and inside of the corner in the 4th year

Zeit in \([d]\)

Rel Luftfeuchte in \([\%]\)

Thickness 600mm - inside corner (2D)
Thickness 600mm – normal wall (1D)
Rijksmuseum Amsterdam

Course of relative humidity and inside of the corner day 730 – January 1st

87.5 % RH
Rijksmuseum Amsterdam

Moisture damages
Profile of water content in the whole construction (built up with 30mm foam glass, 4th year)
Profile of water content in the whole construction
(with 25 mm capillary active inside insulation, 4th year)
All profiles of relative humidity (top) and water content (below) during the 4th year: 30 mm foam glass.
All profiles of relative humidity (prior page) and water content (top) during the 4th year: 25 mm calcium silicate
<table>
<thead>
<tr>
<th>Material</th>
<th>Red. of energy losses (%)</th>
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<tbody>
<tr>
<td>Existing construction (600 mm brick)</td>
<td>-</td>
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<tr>
<td>Foam glass</td>
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<tr>
<td>30 mm</td>
<td>43</td>
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<td>35 mm</td>
<td>36</td>
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<td>40 mm</td>
<td>42</td>
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<tr>
<td>Calcium silicate</td>
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<tr>
<td>35 mm</td>
<td>36</td>
</tr>
<tr>
<td>40 mm</td>
<td>42</td>
</tr>
</tbody>
</table>
Rijksmuseum Amsterdam

Window jamb

Brickwork
Limestone (north-france)
Old painted plaster
approx. 15 - 20 mm
Calcitherm approx. 35 mm
Finish approx. 5 mm

Wooden frame, approx.
100 x 130 mm.
Steel strip 2.1 x 40 mm
Steel strip 45 x 75 mm
Neopreen strip
B1/ P6B anti-burglary glass
Stiletto, thickness by Stiletto

595
495
100
520
910
Day 730 – January 1st