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Development and First Experiences of a Prefabricated VIP-sandwich-element for Fast and Secure Application on Building Surfaces

Content

Aims of this work

Construction of a VIP-sandwich-element

Theoretical analysis

Experimental analysis

Summary and outlook

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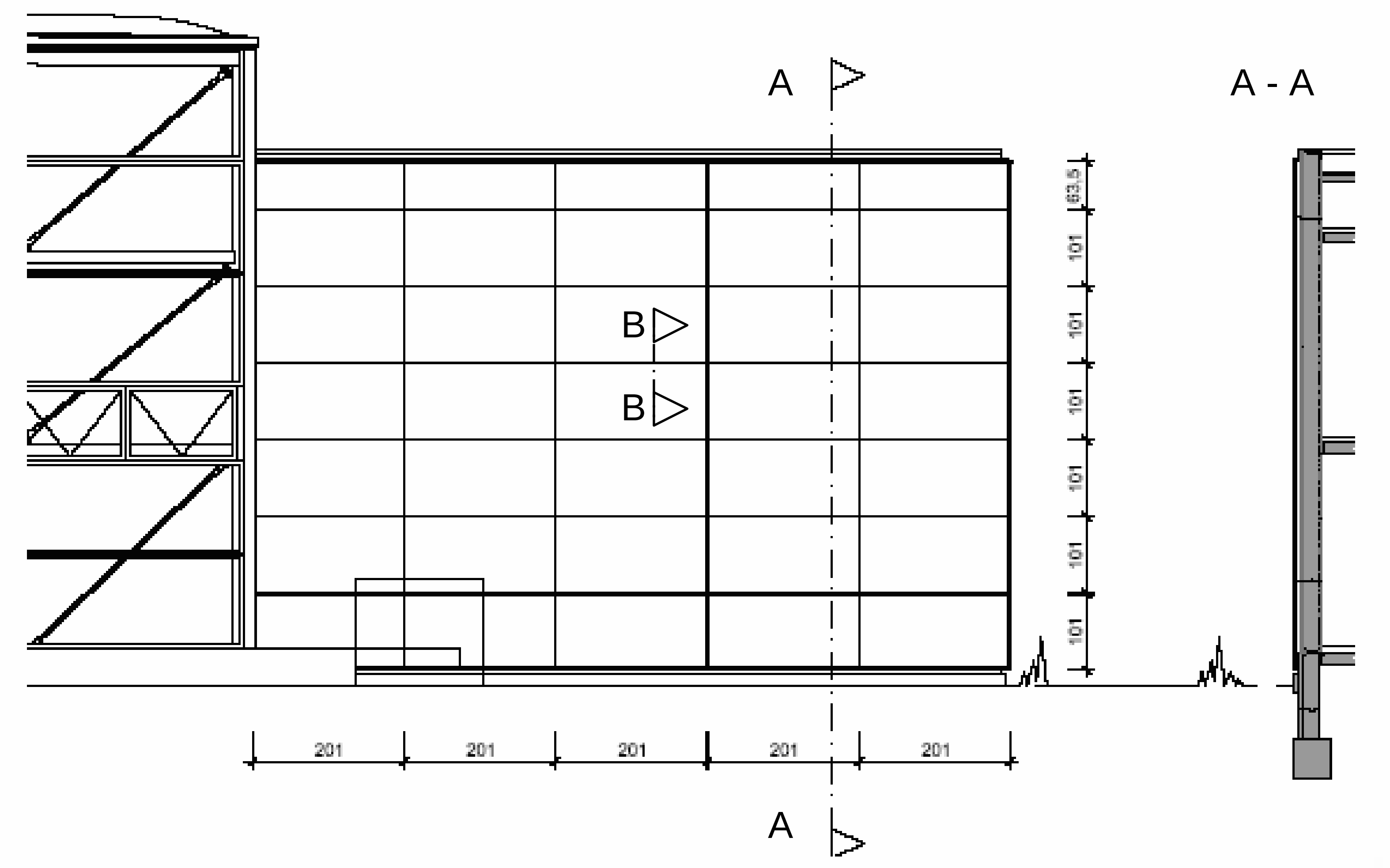
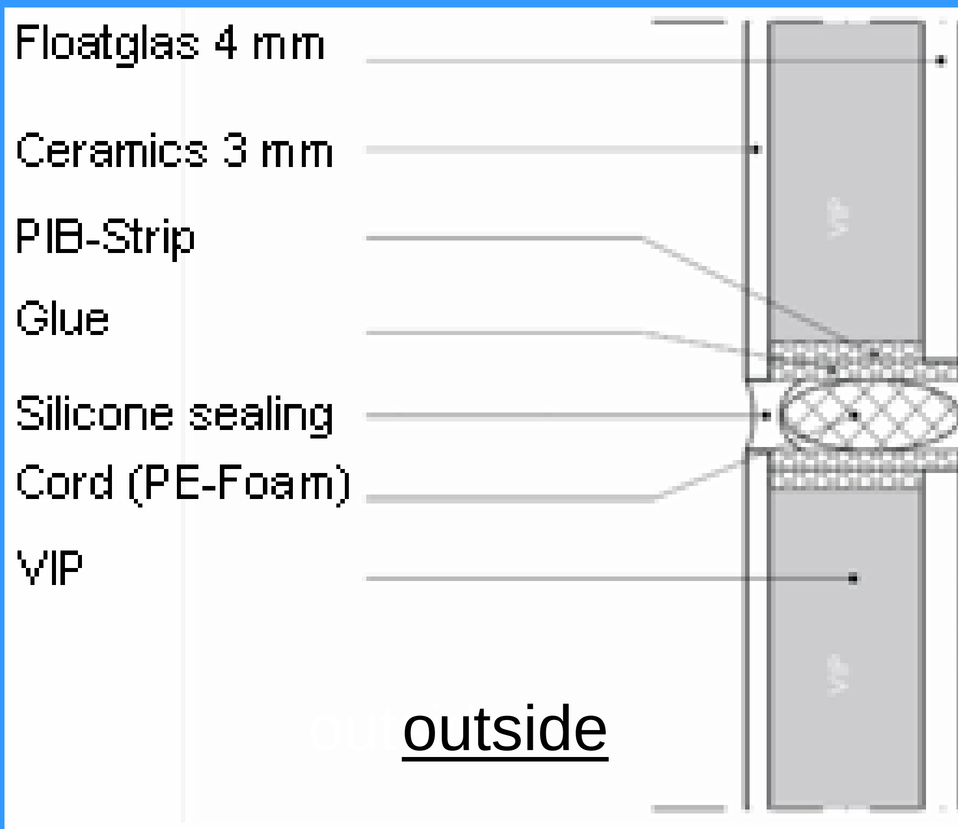
Aims

- using VIP on walls of new / old buildings
- reduced thickness of the insulation layer
- protection of VIPs on the building site and during lifetime
- fast and secure installation on the building site
- possibility of dismounting

Construction and Application

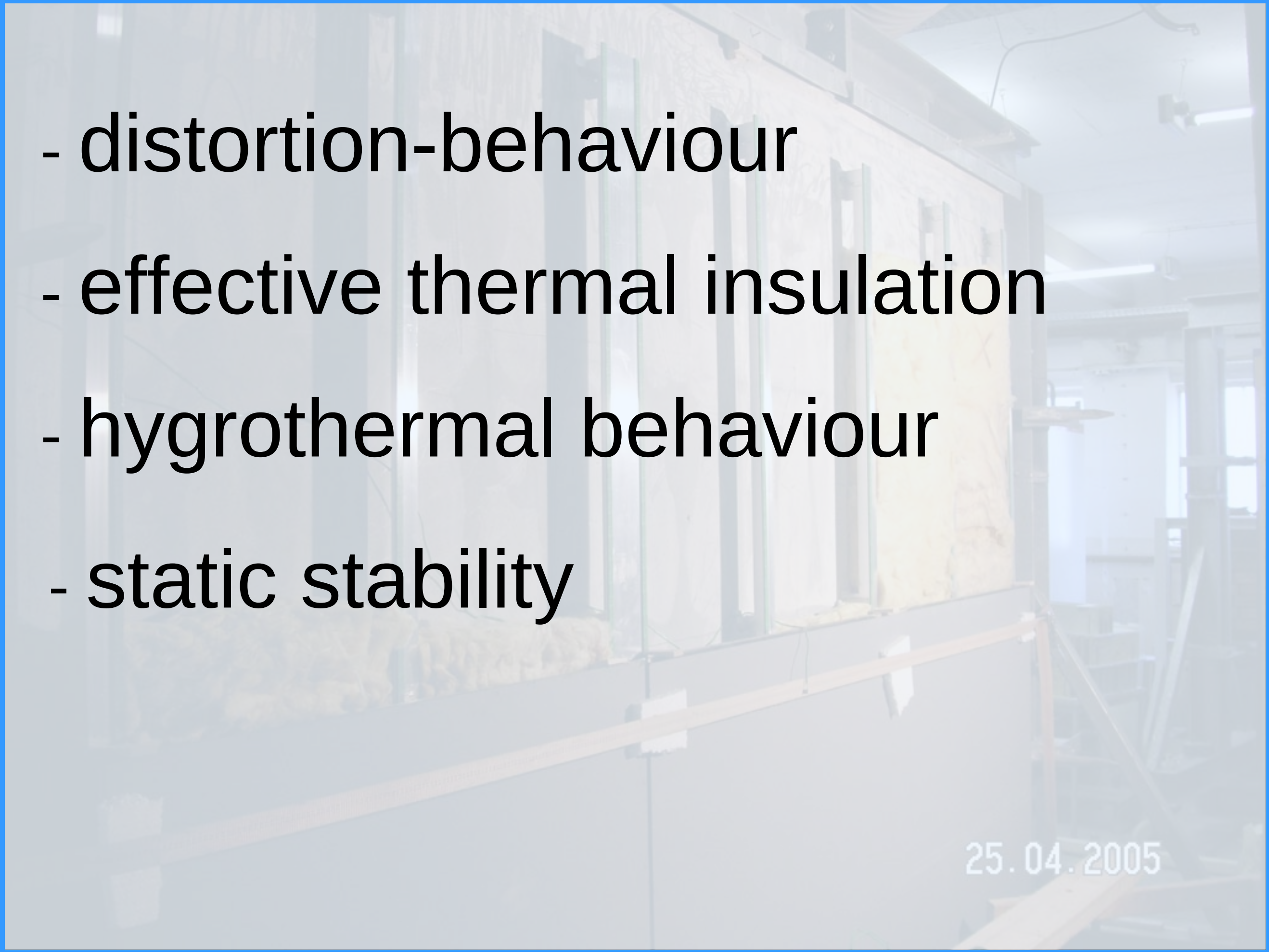


Construction and Application II



Construction and Application III

Aims of investigations

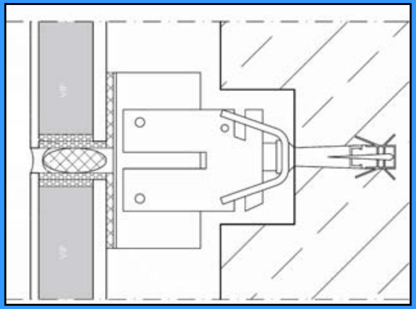


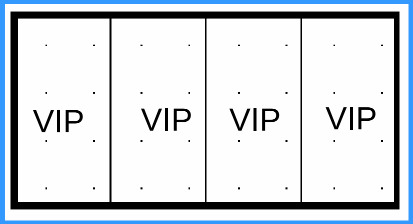
- distortion-behaviour
- effective thermal insulation
- hygrothermal behaviour
- static stability

Theoretical analysis

- distortion behaviour -

- bending
  → continuously held
  → no transmittance of shear forces in centre
- lateral deformation
  → Equation: $\Delta l = \alpha \cdot l_0 \cdot \Delta T$
  → calc. 1,6 / 1,1 mm elongation (glas/ceramics)
- minimal (visible) joint width
  → Compressibility of sealing: 25%
  → Joint width: 8 mm





Theoretical analysis
- thermal insulation -

a) Thermal transmittance coefficient U_{eff}

$$U_{eff} = \frac{U \cdot A + \sum_{k=1}^{K} \psi_k \cdot l_k + \sum_{h=1}^{H} \chi_h}{A}$$

with $\psi = L^{2D} - U \cdot b$ and $\chi = L^{3D} - U \cdot A - \sum_{m=1}^{M} \psi_m \cdot l_m$

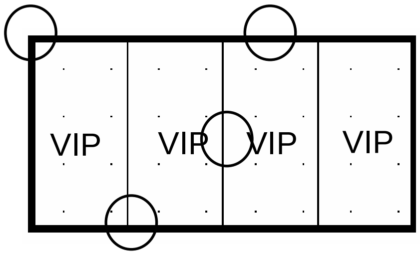
b) Effective thermal conductivity of a VIP-Sandwich-Element
(comparison with conv. insulation, U-Values of composite walls)

$$\lambda_{eff} = \frac{d}{\frac{1}{U_{eff}} - R_{si} - R_{se}}$$

Theoretical analysis
- thermal insulation II -

c) Parameters for calculations

→Thermal conductivity of a VIP:
λ=0,005 / 0,01 mW
→2 linear transmittance coefficients ψ
→2 locale transmittance coefficients χ



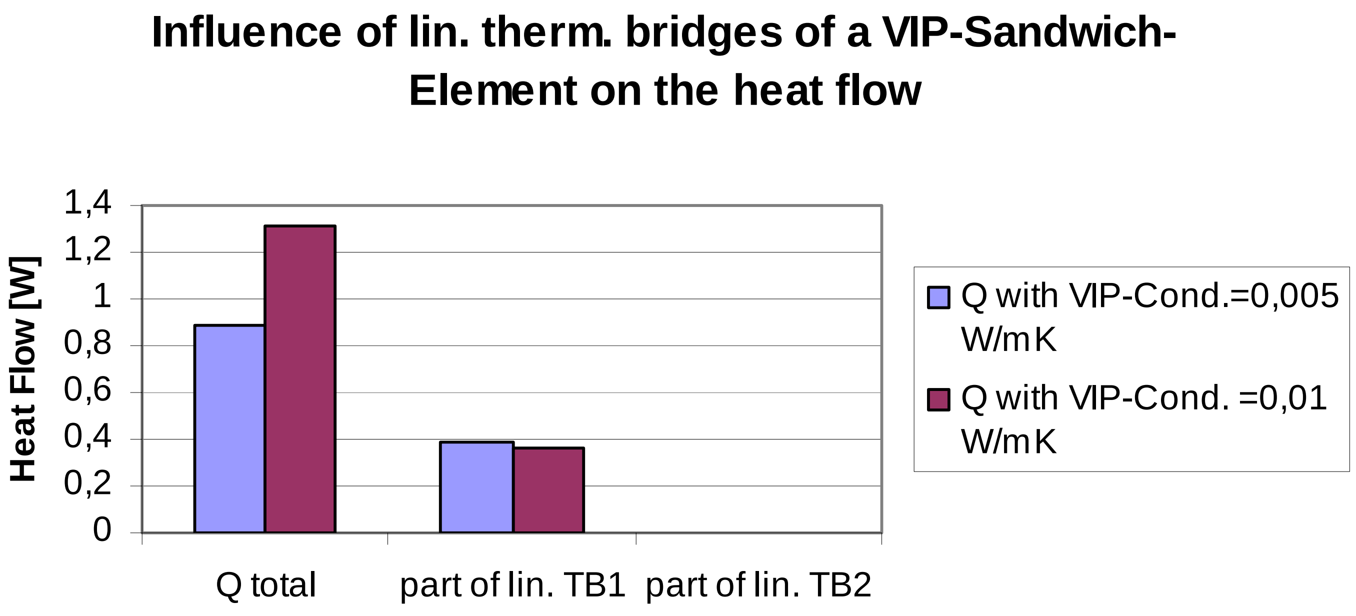
d) Results

Case	a)	b)	Description
λ_{VIP} [W/mK]	0,005	0,01	Conductivity of a VIP within the VIP-sandwich
U_{eff} [W/m²K]	0,430	0,630	Effective thermal transmittance of the VIP-sandwich
λ_{eff} [W/mK]	0,0125	0,0190	“overall” conductivity of a whole VIP-sandwich-element

Theoretical analysis

- thermal insulation III -

d) Results…



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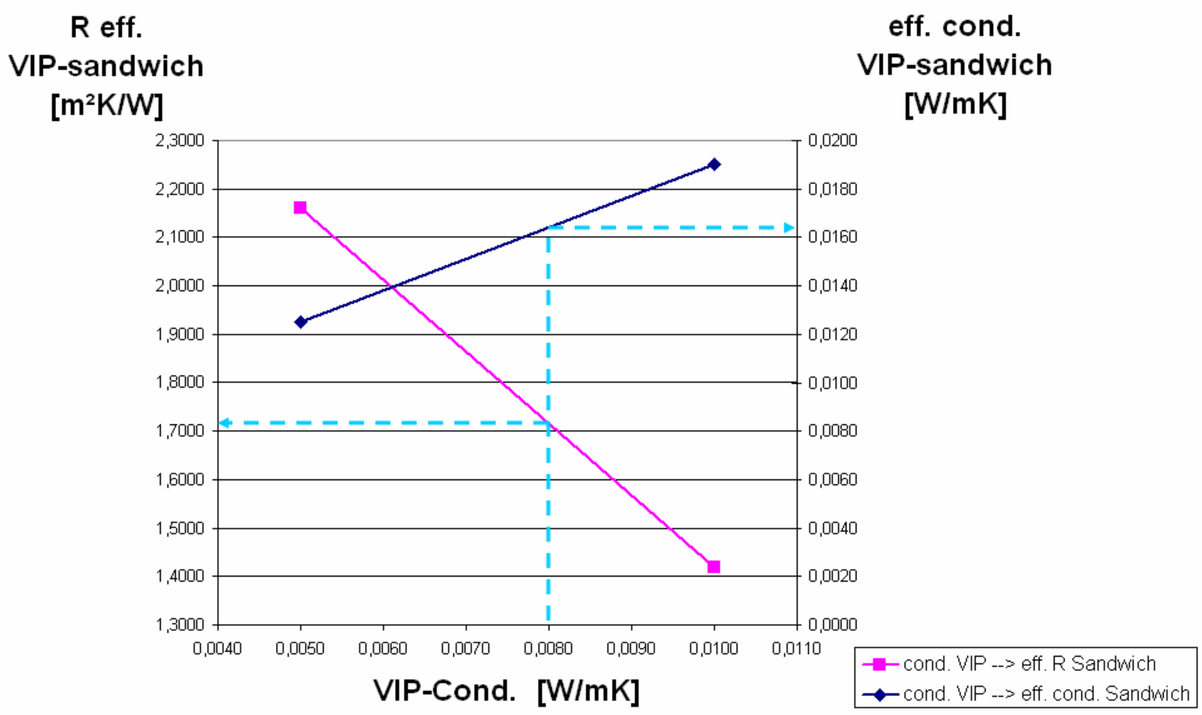
Theoretical analysis
- thermal insulation IV -

d) Results…



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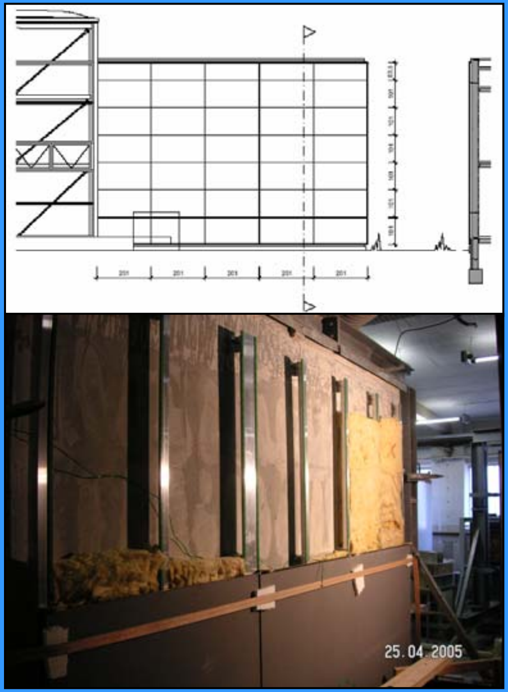
Theoretical analysis

- hygrothermal behaviour -

a) Risk of condensation calculated for an existing wall of

-20 mm cement plaster
-200 mm lightweight concrete (λ=0,36 W/mK)
-60 mm concrete

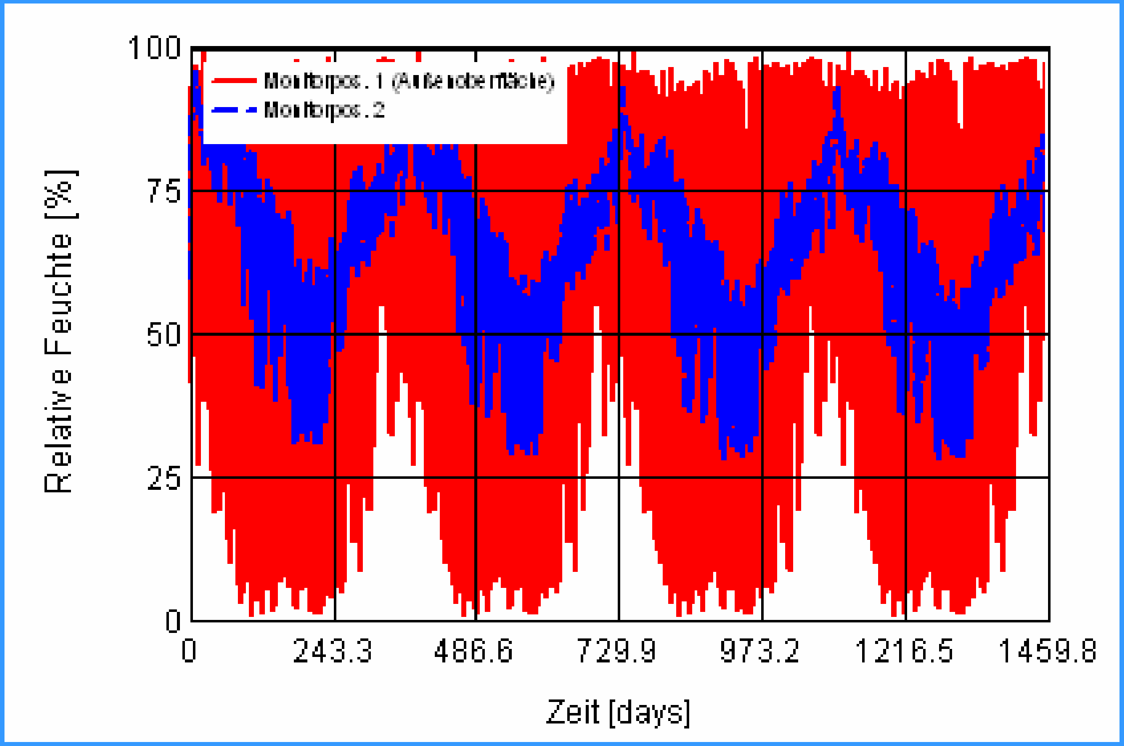
faced with a VIP-Sandwich-Element

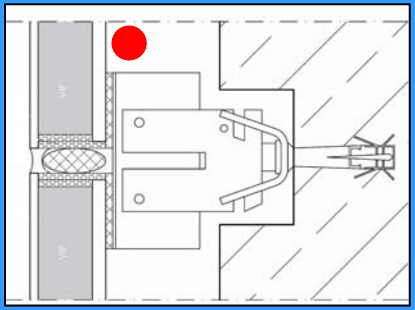


b) Parameters for calculation

-VIP-conductivity of λ = 0,01 W/mK
-VIP-conductivity of λ = 0,019 W/mK (damaged)
-Condensation risk within the joint (not content)

c) Results for <u>not damaged</u> VIP (λ=0,01 mW)

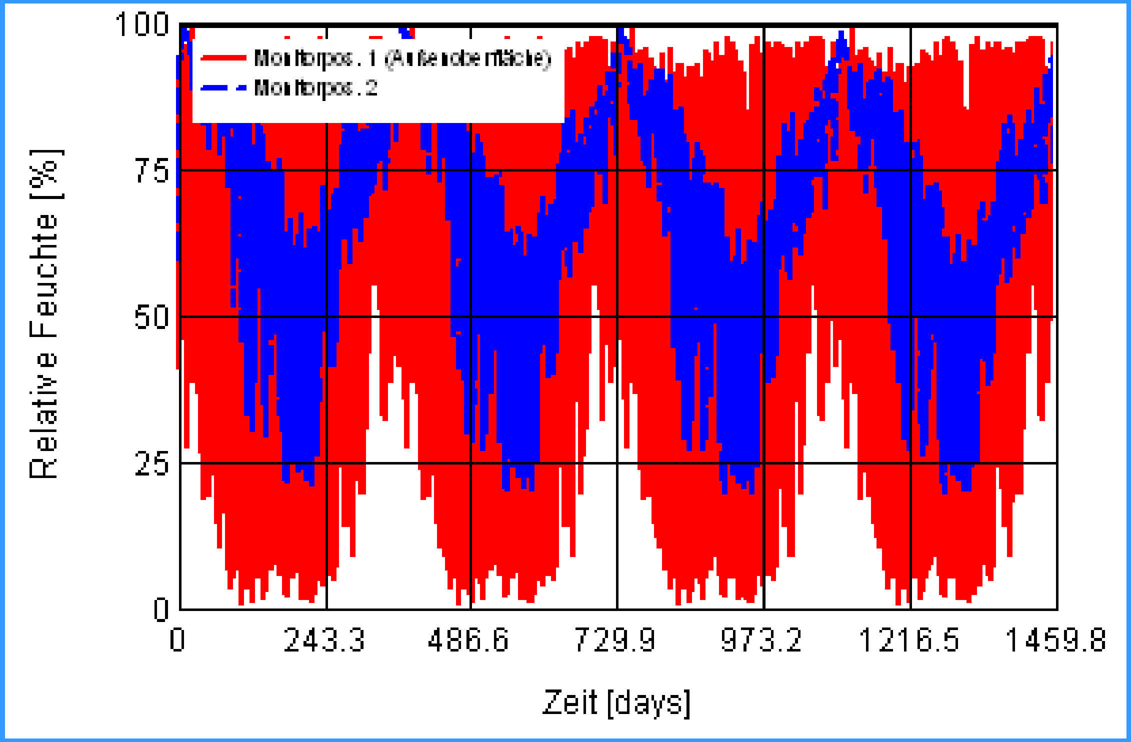


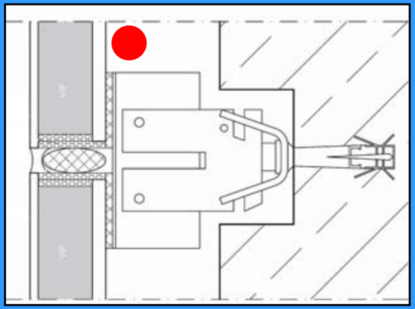


Theoretical analysis

- hygrothermal behaviour -

d) Results for <u>damaged</u> VIP (λ=0,019 mW)





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Experimental investigations

Experimental set up – testing wall in the climate chamber

Specimen:
- -100 mm concrete
- -60 mm mineral wool
- -30 mm VIP-Sandwich-Element

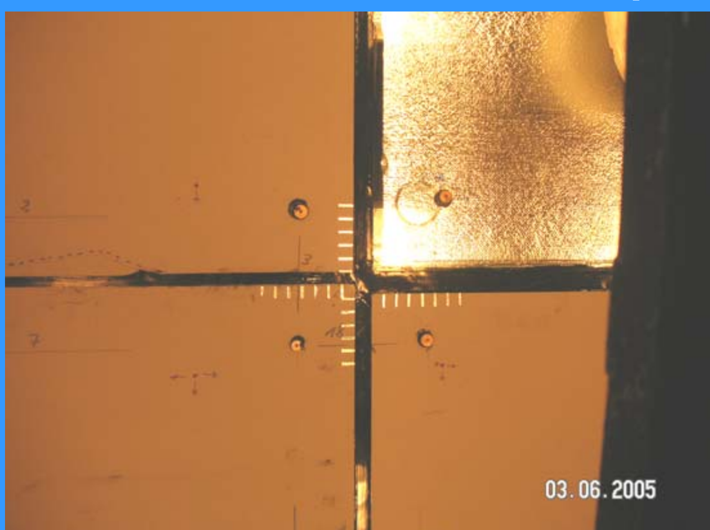
Conditions:
- -Warm side 20°C
- -Cold side -5 °C

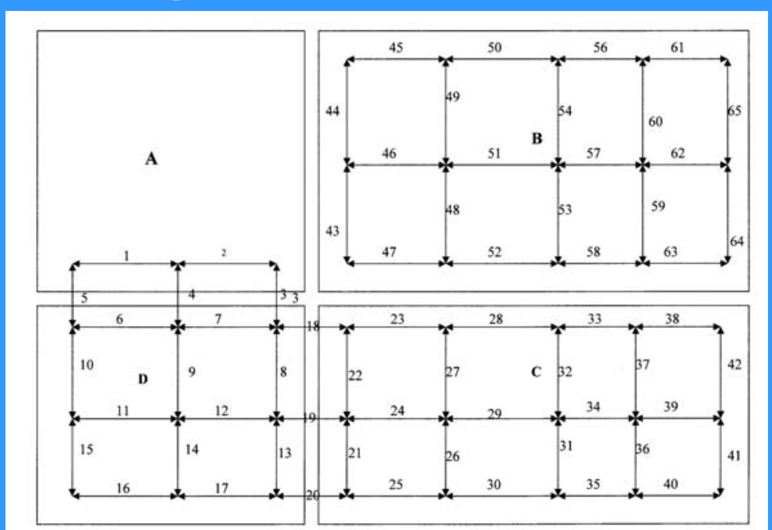
Experimental investigations

- Distort behaviour -

- bending of VIP-Sandwiches
  - →Under steady state conditions a simple “straight edge” were used
  - →No visible bending

- lateral deformation (elongation)

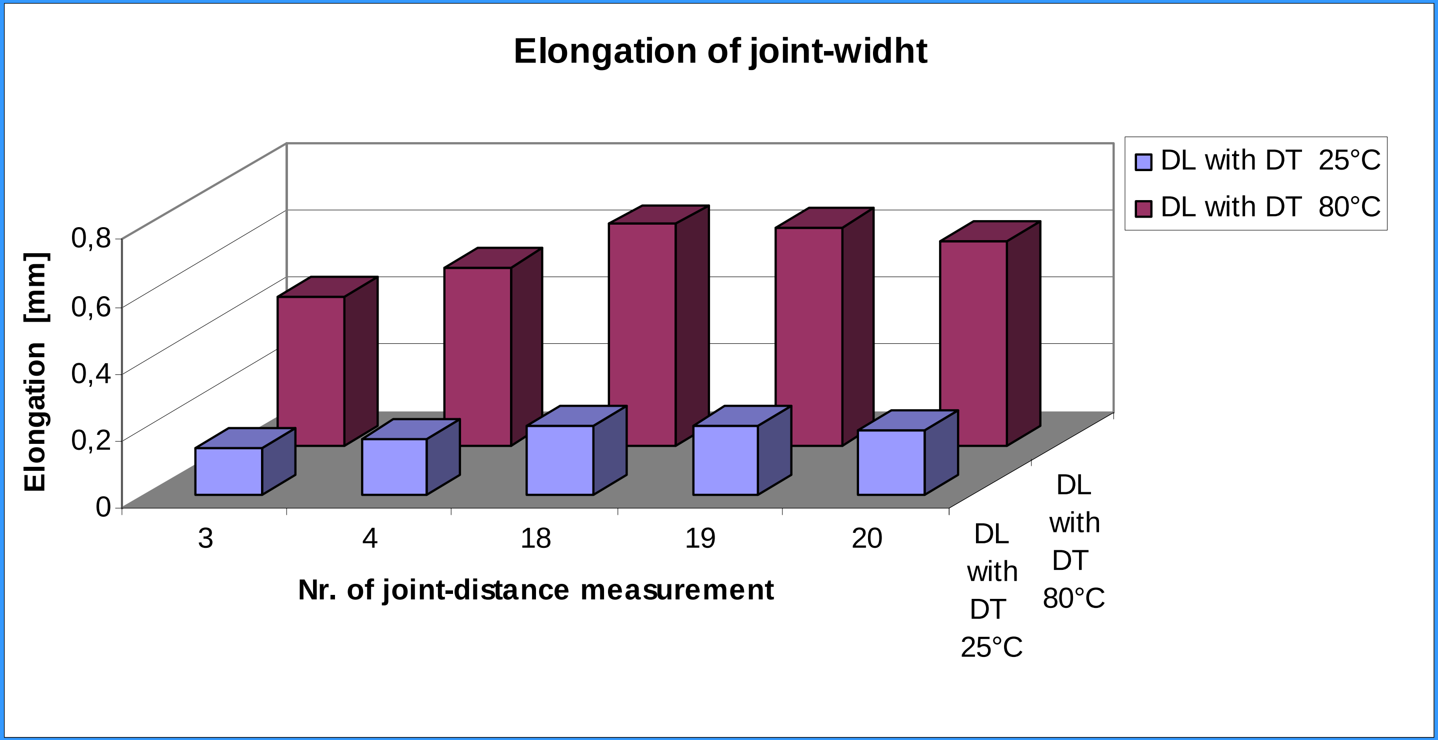




Experimental investigations

- Distort behaviour -

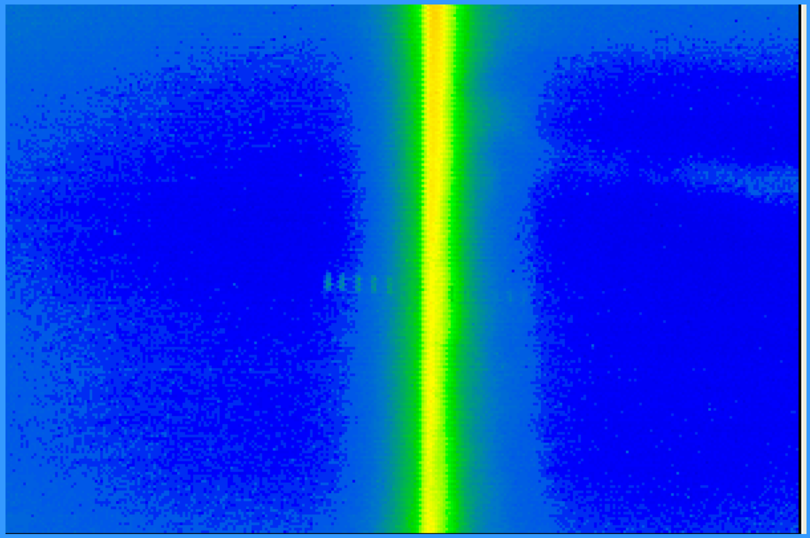
- lateral deformation…



Experimental investigations

- effective thermal transmittance -

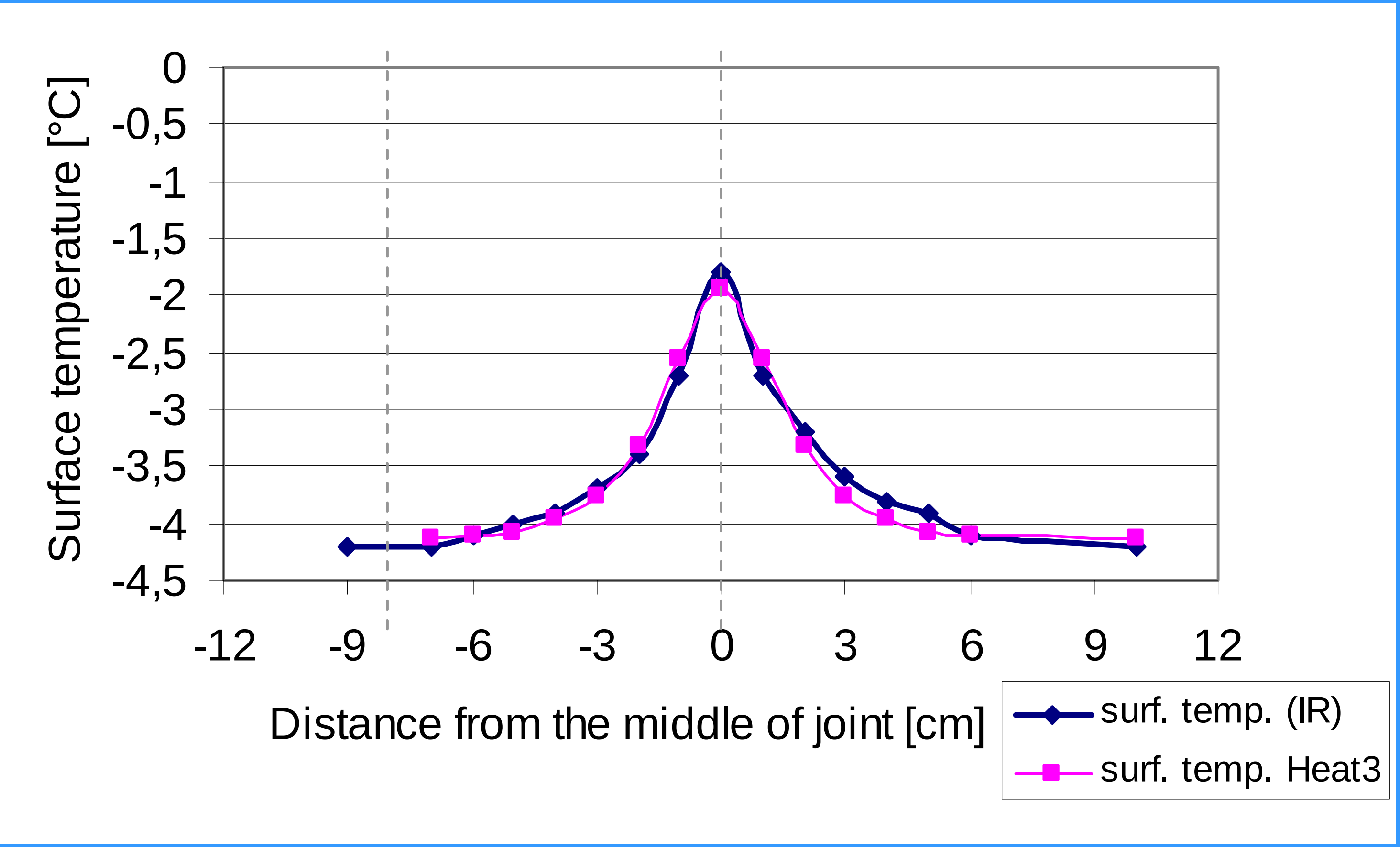
- Linear thermal bridge around a VIP-sandwich has the most influence
- Comparison between calculated and IR-measured temperature spreading over a joint
- metal strips were glued on the testing wall to “straighten out” an IR-picture



IR-picture of a joint between two VIP-sandwiches

Experimental investigations

- effective thermal transmittance II -



Experimental investigations

- static / stability -

Summary and outlook

Theoretical and experimental investigations of distort behaviour, effective thermal transmittance, risk of condensation and stability of a VIP-Sandwich were done

It can be assumed that
- the bending of the whole element is low
- a minimal visible joint width of 8 mm is possible
- there is not an enrichment of water behind the VIP-Sandwich due to condensation
- the effective thermal transmittance coefficient U_{eff} shows usable results

Summary and outlook II

Further investigations has to be done with follow aims:

- reducing the thickness of the cavity behind the VIP-Sandwich (now fulfilled with conv. Insulation)

- risk of condensation “in practice” (preparation of a monitoring in a test building)

- Observation the long time stability of a VIP-Sandwich and of a VIP itself

Thank you for your

attention !