Zukunft Bau

Summary report

Title

Vacuum insulation panels (VIP) in building practice: from the insulation material to the insulation system

Processing, fastening, durability

Occasion / initial situation

Vacuum insulation panels (VIP) are high-performance insulation materials with very low thermal conductivity. In comparison with conventional insulation materials (rigid foams, mineral wool), VIP with design values of approx. 0.007 W / (m K) reach a thermal conductivity which is lower by a factor of 5. With these properties, lean, yet energy-efficient components can be realised. Despite these advantages, VIPs have so far been reluctantly used in construction. Obstacles and reservations result from the skepticism regarding the quality and durability of the panels and the heat brigade problems of the fasteners and the associated planning effort.

Subject of the research project

For the detection of obvious defects, for example, in the area of sealed seams of the VIP, there are reliable, rapid test methods, which are carried out as quality assurance measures in the plants. But also a faultlessly produced VIP is subject to a creeping pressure rise due to the inevitable permeation of dry air gases and water vapor. Since the internal pressure of VIP directly influences the thermal conductivity of the panels, this behavior is crucial in evaluating the aging of VIP.

In In a laboratory test, the internal pressure and heat conductivity increase of VIP was determined for panels stored at different constant climates. By means of hygrothermal simulations, the occurring climatic conditions for VIP in multiple building applications were analyzed at representative locations, and an aging model for the description of the increase of internal pressure and thermal conductivity during a useful life of 50 years was developed. Figure 1 outlines the systematics of the research approach.

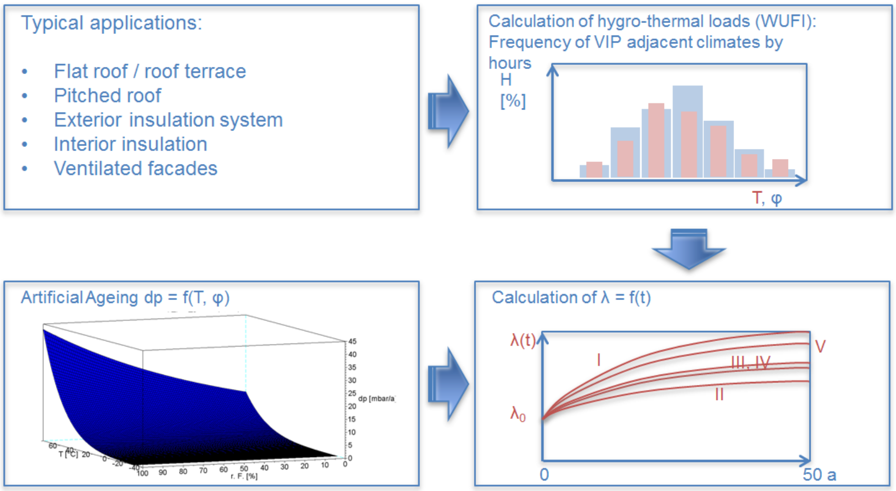

Figure 1 **Sketch for research approach to examine the durability of VIP elements under normal humidity and temperature conditions in building applications**

When using VIP, thermal bridges arise at the joints between the panels (linear heat bridges) and through the fasteners used, such as dowels, mounting brackets, etc. (point thermal bridges). The combination of VIP with edge strips and claddings to improve the handling during the installation process and the protection of the VIPs' barrier film from mechanical damage has an influence on the thermal bridging effects at the joints.

In order to determine the relevant influencing factors, a systematic study by means of numerical calculation was carried out on the influence of the parameters mentioned. Different materials (aerogel, EPS, calcium silicate) and widths for the edge strips as well as different materials for the claddings (XPS, GFK, metal) were combined. To investigate the point thermal bridges, a generic dowel was modelled, which was combined with the variants mentioned above. In this way, point and linear thermal transmittance values were determined as well as the effect of the thermal bridges on the thermal transmittance U.

Figure 2 shows the half-section of the generic dowel in a composite element based on a 40 mm VIP with 5 mm cladding of XPS and a 10 mm wide edge strip

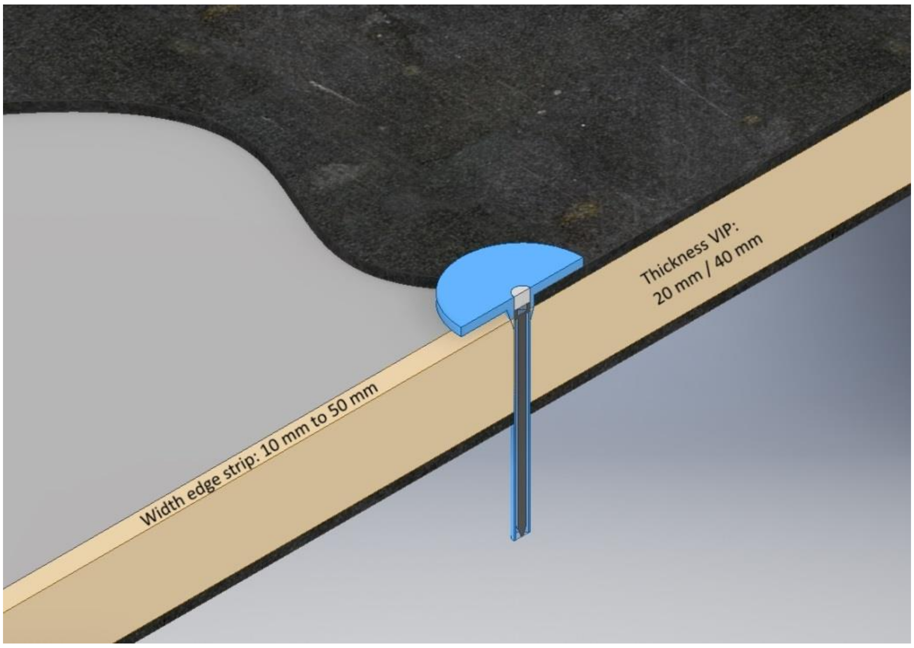

Figure 2: **Generic dowel in the sandwich element with an area of A = 0.50 m². The half-section with dowel in the element with a 40 mm VIP core and a 10 mm wide edge strip.**

Since in spite of all care in the manufacture of the panels and the handling on the construction site, the possibility of damage to individual VIPs cannot be completely eliminated, the influence of ventilated panels on the heat transfer of the insulated surface was also investigated.

Thereby two different questions were regarded. On the one hand, the influence on the average U-value was examined. The question of energy performance is at the forefront. On the other hand, the influence of ventilated panels on the minimum thermal protection was also investigated with regard to a possible localization of the minimum temperatures on the inside of the component, the focus being on the freedom of condensation and the prevention of mold growth.

For the study, the thermal bridge calculations were varied by modeling different combinations of ventilated and intact VIPs.

Conclusion

The results of this research show that state of the art VIPs can easily achieve a building-specific service life of 25 - 50. The investigation is based on a model of thermal conductivity progression developed from laboratory tests of pressure increase at constant climates.

During service life, the thermal conductivity increases with a declining rate. Depending on the application and location, an average thermal conductivity during the first 25 years of use ($\lambda_{m,25}$) of approx. 0.0055 – 0.0067 W/(m K) and during the first 50 years of use ($\lambda_{m,50}$) of approx. 0.0064 – 0.0081 W/(m K) is obtained (figure 3). These results show that for the VIPs used in this study their design value of thermal conductivity of 0,007 W/(m·K) is a conservative assumption even for the most unfavorable use cases.

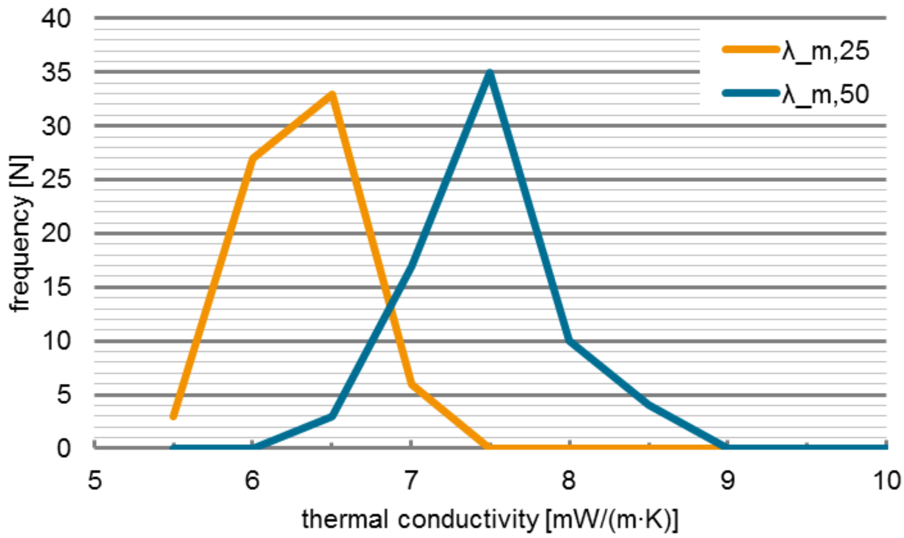

Figure 3 **Frequency of thermal conductivity in the investigated applications at a panel thickness of 20 mm (a larger panel thickness reduces, smaller panel thicknesses increase the thermal conductivity values):**
$\lambda_{m,25}$ = average value during the first 25 years of use
$\lambda_{m,50}$ = average value during the first 50 years of use
(a total of 69 variations were analyzed)

Regarding the influence of the fasteners on the heat transfer, it can be noted that in many cases no further consideration of the point thermal transmittance of the anchors is necessary for applications as ETICS and interior insulation. Constructions with more solid and therefore thermally less unfavorable fasteners (e.g. L-brackets for curtain wallings, distance pins in double-walled concrete constructions) require a consideration of their thermal transmittance in the U-value.

VIPs with core material made of fumed silica provide sufficient application safety, not causing energetic or hygienic problems, even in case of ventilation of single panels. By using edge strips and cover layers, VIP is also becoming safer to handle without influencing the thermal performance.

Basic data:

Short title:	Vacuum insulation panels (VIP) in building practice: from the insulation material to the insulation system
Researcher/ project management	
	Dipl.-Ing. Christoph Sprengard (project management) Dr.-Ing. Sebastian Treml Max Engelhardt B. Eng. Dipl.-Ing. Holger Simon M.BP. Dipl.-Ing. Florian Kagerer
Total cost:	93,500.00 Euro
Share of federal subsidy:	53,5 %
Project term:	01.10.2012 – 31.07.2016

PICTURES/FIGURES:

Figure 1

File name:
Caption: Sketch for research approach to examine the durability of VIP elements under normal humidity and temperature conditions in building applications

Figure 2

File name:
Caption: Generic dowel in the sandwich element with an area of A = 0.50 m². The half-section with dowel in the element with a 40 mm thick VIP core and a 10 mm wide edge strip.

Figure 3

File name:
Caption: Frequency of thermal conductivity in the investigated applications at a panel thickness of 20 mm (a larger panel thickness reduces, smaller panel thicknesses increase the thermal conductivity values): $\lambda_{m,25}$ = average thermal conductivity during the first 25 years of use $\lambda_{m,50}$ = Average thermal conductivity during the first 50 years of use (a total of 69 variations were analyzed)