Summary report

Title

Extended Version Title: **„Development of a simplified evaluation procedure for the determination of the thermotechnical properties (U-value, g-value) of membrane envelope constructions“**

Cause / Initial situation

443/450 letters incl. blank spaces

Ultralight constructions are increasingly establishing themselves in the construction sector. In contrast to conventional solid constructions, there are no dimensioning and testing methods adapted to these constructions to determine their thermotechnical properties. This project developed and validated simplified thermotechnical design methods for ultralight structures, in particular for membrane cushioning and textile multi-layer systems.

Subject of the research project

Description of the work steps and the solution process
2.373/4.300 letters incl. blank spaces

The overall objective of the project was to provide a practicable and easily applicable design method for the thermotechnical behaviour of ultra-lightweight structures, in particular textile multi-layer and membrane cushion structures. Such a procedure is of particular importance for the energetic evaluation within the framework of the public-law verification (EnEV) and should be able to be incorporated into the relevant verification procedures (e.g. DIN V 18599).

Due to the large scope of questions to be clarified, the project was thematically divided into two project parts, which were worked on in parallel at the Fraunhofer IBP (transparent membrane cushion constructions and translucent lightweight panels) and at the ILEK of the University of Stuttgart (opaque textile multi-layer systems and adaptive glazings).

Within the context of extensive metrological analyses on test specimens, the essential influences were identified under realistic operating conditions which determine the thermotechnical behaviour of the considered ultra-lightweight constructions. For this purpose entire components, if necessary including frames (or clamping profiles for membrane constructions) were considered. The focus of the work at the Fraunhofer IBP was on in situ measurements of large, transparent membrane cushions. These measurements were carried out on the calorimetric façade and roof test stand of the Fraunhofer IBP. The work at the ILEK, however, focused on switchable glazing and textile multi-layer systems. From the comparison of the results of the measurements under real installation geometries and the laboratory measurements on a reduced scale, conclusions were drawn about the extent to which common laboratory tests, together with established calculation methods, are suitable for determining the energetic properties and which modifications are necessary regarding test and calculation specifications. After it became apparent that plane-parallel lightweight components such as polycarbonate sheets and switchable glazings were already being taken into account in standards with the accuracy usual for other building products, the main focus of the project was on textile multi-layer systems and pneumatically stabilized

membrane cushion constructions. For these two construction types, adaptations of the established evaluation procedures were developed.

Conclusion

Descriptions of planned objectives and achieved results
695/700 letters incl. blank spaces

The standards already take sufficient account of multi-skin sheets (g- and U-values).
DIN EN 410 can be applied without restriction to membrane cushions; DIN EN ISO 6946 and DIN EN 673 (U-value) can be applied to membrane cushions if long-wave transmission is taken into account. An adaptation of the established calculation method has been developed.

For the U-value of textile multi-layer systems, a method is already available (Layer-Tool, ILEK), which has been investigated with regard to its applicability.
Adaptive glazings can be designed with DIN EN 410 (g-value) and DIN EN 673 (U-value), if the variable transmission and absorption values dependent on the switching stages are considered.

Key data

Short title:	Evaluation procedure membrane envelopes
Researchers/ Project management:	Andreas Kaufmann (IBP), Dr. Walter Haase (ILEK) Dr. Matthias Kersken (IBP) Almuth Schade (IBP) Herbert Sinnesbichler (IBP) Clemens Freitag (ILEK) Florian Hess (IBP) Angela Püls (IBP)
Total costs:	444.580,09 €
Share of federal subsidy:	305.252,68 €
Project duration:	24 months

IMAGES / FIGURES

5 – 7 Druckbare Bilddaten als eigene Datei (.tif, *.bmp,…) mit der Auflösung von mind. 300 dpi in der Abbildungsgröße (z.B. Breite 10 – 20 cm). Bilder frei von Rechten Dritter.*
Bildnachweis jeweils:

IBP

Image 1: Bild1_KalorimerterIBP.JPG
Measuring box of the calorimetric façade and roof test stand with a pneumatically supported, two-layer ETFE membrane cushion in the test specimen opening.

Image 2: Bild2_Thermographie.png
Left: Source thermographic image of the second membrane test specimen from 11.01.2017 with the white marked section line for the temperature profile.
Right: Temperature profile of the edge area - The curve shows the course of the surface temperature over the membrane cushion at a distance from the piping.

Image 3: Bild3_UWerte.png
Comparison of the calculated (black) with the U values determined by calorimetry (red) and by heat flow discs (orange) in the middle of the cushion. The calorimetrically determined U-values, which also contain the thermal bridges of the cushion edge and the clamping profiles, are also shown in cyan. The addition "wML" to membrane 1 stands for an inwardly folded centre position of membrane test specimen No. 1. The measurement uncertainty is indicated as a simple standard error.

Image 4: Bild4_gWerte.png
Depiction of the measured (orange) and normatively determined (blue) g-values. Indication of the measurement uncertainty as a simple standard error.

ILEK

Image 5: Messbox ILEK.png
Schematic structure of the heating box according to DIN EN ISO 8990.

Image 6: Dachprüfstand ILEK.png
Exemplary section through the roof test stand with a three-layer structure including depiction of the sensor positions.

Image 7: adaptive Verglasung ILEK.png
Façade test stand on the open-air test area of the
ILEK: External perspective south-west (left picture), internal perspective with
view to the south (right picture).