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Windows and Facades suitable for use
Construction principles for new developments

1 Introduction

Apart from the aesthetic considerations windows and facades, as transparent construction components in the building shell, must also fulfil requirements in connection with mechanical strength and stability, fire protection, hygiene/ health/environmental protection, safety of use, sound insulation as well as thermal insulation and energy savings. This complex profile of requirements places the highest demands on the conception of the products. Since the characteristics are partially affected by one another, or, at times, are mutually exclusive of one another, there is no absolute optimum. Each construction element thus always represents a compromise between the desired characteristics. To develop new products, an innovation process is required, which leads to a new product. In this sense, innovation is, in the interpretation of Joseph A. Schumpeter [1] (a reputed national economist), the establishment of a technical and organisational innovation, and not merely its invention. As a result, innovation could also represent the combination of already known technologies leading to a new product. The innovation process is divided into three basic phases:

- The impulse phase, in which trends and futuristic technologies can be observed.
- The evaluation phase, in which the suitability of the technologies for the particular industry, or the owned product or manufacture is assessed.
- The technology transfer, with which the relevant technologies and organisational solutions are implemented.

The objective is always to achieve a monopoly position with the innovation – even if this is only for a short period – which facilitates higher prices or increased productivity with the deployment of the same or reduced material and/or manpower.

2 Construction Principles

Innovation processes based on these viewpoints, apart from the new technologies, must comply with construction principles, which ensure the function and suitability of use of the end product.

2.1 Function-oriented use of materials – Level model

As a result of the clear assignment of the functional levels, it is possible to use materials corresponding to the specified requirements and matching their capacity. In this manner, at the level of the outdoor exposure, weather-resistant materials may be used, which are largely capable of withstanding the stipulated loads and stresses. At the functional level, optimised materials are used to cater to the specific requirements in connection with thermal insulation, leak tightness, structural design, supports for harware and glass, etc. At the decoration level, practically any type of material may be used, which would not have been considered at the other levels. On principal, we differentiate between the discrete and the monolithic construction of such systems. A typical example of the discrete construction is that of

timber metal windows, divided into a) a weather-resistant outdoor component made of metal; b) a component providing excellent thermal insulation and a statically optimised area made of, for example, coniferous wood, and c) a decorative indoor portion made of, for example, deciduous wood. A typical example of monolithic construction is a three-ply profile made of different types of wood.

2.2 Spatial separation of functional levels

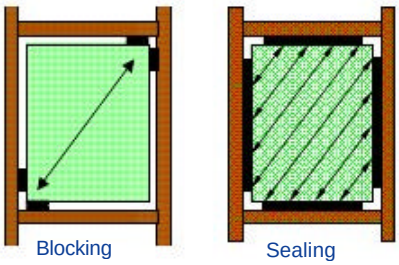
Other examples of the level model construction, used successfully for many decades now, are, e.g. the outdoor window sill interface or the drainage system, with which the weather-resistant and the leak-proofing levels are consequently separated. Areas requiring optimisation in this context are the internal casement overlaps of wooden windows or the glazing bead: In the years gone by, owing to weather-proofing against the internal climate not implemented consistently, and as a result of increasingly leak-proof building shells, there were cases of damage arising out of entry of moisture in the rebate areas. These problems, however, can be overcome easily by means of the spatial functional separation, whether it is with the use of overlap gaskets or by avoiding joints on the indoor side. In this manner, for example, the leak-proofing of the glazing bead can be substantially improved by means of glazing on the outside. Possible approaches towards a solution, which have been time-tested, include glued glazing systems or metallic covering shells fixed from the outside for fixing the insulating glass unit.

2.3 Glass as a stiffening element

In recent times, many windows systems have been introduced in the market, where the insulating glass unit is also used for stiffening the casements. Apart from the improved stiffness of the casement member in the direction of the glass level, there are also other additional effects such as, for example, improved burglary resistance, omission of the glazing bead or a reduction in the maintenance costs of the casement on the outside. With the use of this new construction style, in any case, serious consideration should be given to the compatibility of the components used, as well as to the application of the adhesive materials. Only when the adhesive is applied under defined conditions to accurately prepared join partners, a long-lasting and uniform bonding can be assured. To

Possible solutions:

- Blocking
- Adhesive sealing



Analytical methods:

- Polarised light
- Finite Element Method (FEM)

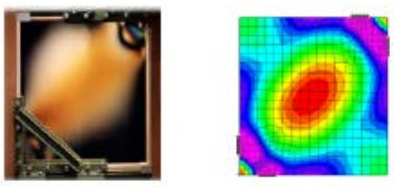
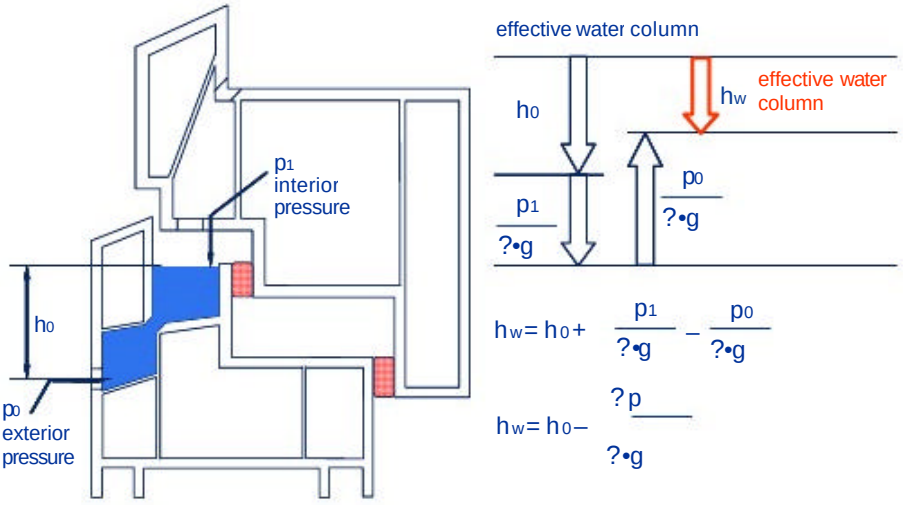


Figure 1
Principle of Construction:
Glass as a Stiffening Element

ensure the durability of the materials used, in each case an exact definition of the materials and systems used is required, which includes mutual information disclosure both by suppliers and clients[5]. To prevent damage as far as possible, it should be ensured that the systems used, in any case, conform to the "ift Guidelines for glued glazing systems".

2.4 Pressure equalisation and rise of water

The infiltration of rainwater via the functional joints in the construction cannot be totally eliminated in the case of windows and facades. Thus, it is imperative that a second sealing surface be implemented in window and facade systems. To ensure reliable water discharge from the construction, theoretically, one must provide a rise of water of 10 mm per 100 Pa pressure differentials between the rebate area and the external pressure. Since, in practice, it is very difficult to achieve this, a trick is used: The pressure differential between the rebate area and the external climate is reduced by means of pressure equalisation holes, which are arranged in the rain-protected areas. In this manner, constructions achieve higher outflow quantities and thus, a higher classification of watertightness. Even the size and placement of the drainage holes play a decisive role in the drainage volume that may be implemented. Investigations at ift Rosenheim[3] have shown, that holes drilled less than 8 mm in diameter or slotted holes, which are smaller than 5 x 20 mm, achieve only inadequate water discharges owing to the surface tension of water, and are, thus, not suitable. What has a positive effect on the water discharge is the drainage via front chambers and via laterally displaced water flow slits. In the case of stick constructions, the transoms are opened at the top on purpose, to enable pressure equallisaton and to achieve good ventilation (chimney effect).



g [m/s²] Gravitational acceleration (9,81 m/s²)
h_w [m] Effective pressure head
h_0 [m] Height of the liquid column above the outflow
p_0 [Pa] Pressure on the water column from outside
p_1 [Pa] Pressure on the water column in the rebate
? [kg/m³] Density (Water 1000 kg/m³)

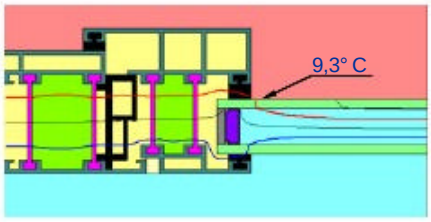
Figure 2
Principle of construction: Effective water column

2.5 Increased glass penetration into the frame

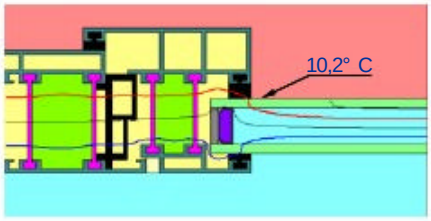
If you compare the surface temperatures of two identical window systems with respect to the boundary conditions in accordance with DIN 4108-2 for the calculation of f_{RSI}, then, as a result of increasing the glass penetration into the frame by 3 mm in the case of a thermally insulated aluminium window, with an aluminium spacer system in the pane edge area, you obtain a 0.9° C higher surface temperature at the border of the glass [6]. Based on this, you can positively influence the dew point characteristics of window constructions by means of a simple modification in the construction.

2.6 Thermal separation on one level

Offsets between the thermal breaks for metal windows, e.g. between the casement and the frame member or, in the case of stick constructions, between the insulator and the spacers of the insulating glass units, result in non-linear run of the isotherms (lines of identical temperature) in



The course of isotherms with 15 mm glass penetration into the frame



The course of isotherms with 18 mm glass penetration into the frame

Isotherm runs were calculated as per DIN 4108-2 (f_{RSi}).

Boundary conditions:
outside: ϑ_{ne} = - 5° C, R_{se} = 0,04 m²K/W
inside: ϑ_{ni} = 20° C, R_{si} = 0,13 m²K/W

Figure 3
Principle of Construction: Increased glass penetration into the frame; a higher glass penetration into the frame reduces the risk of condensation at the edging of the glass

Thermal separation offset against one another

U_f = 3,2 W/(m²K)

Thermal separation in one level

U_f = 3,1 W/(m²K)

Figure 4
Principle of Construction : Thermal Separation in One Level; Isotherms laid in a straight line as far as possible improve the U_f value

the construction cross-section. By means of arranging the thermal break in window systems on one level and the resulting linearisation of the isotherms, the U_f-value of otherwise identical window and facade constructions can be improved significantly.

3 Summary

With the help of the intelligent combination of known and proven construction principles in conjunction with new trends and inventions, innovative window and facade constructions can be developed which, as a whole with respect to its features, represent innovations. What is decisive with each innovation is that the opportunities and risks are estimated reliably and its implementation is carried out in sales and marketing as well The comprehensive testing of the characteristics and the assessment of the durability under adverse climatic and mechanical conditions and loads is an indispensable means to minimise the risk of complaints. A product, which, on account of inadequate market maturity, earns a bad reputation, apart from the financial losses incurred, is finally, also practically no longer capable of being sold. This fact remains, even when the faults and shortcomings have been rectified subsequently.

In the last 40 years a multitude of experiences and research results have been collected at ift Rosenheim, which the industry can put to good use for itself, and which has made the German windows and facades industry one of the market leaders in the world. You may use this knowledge to develop new products and to ensure their success prior to their launch in the market. Constant innovation is the one and only competitive advantage, which is an asset in the long run!

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Useful information in brief

Seven construction principles for windows and facades suitable for use

1 Use material matching the characteristics:
- Weather-resistant materials for outdoor areas
- Materials with good static and physical construction features at the functional level
- Decorative materials on the interior side

2 Spatial separation of functional levels:
Weather-proofing and sealing should always be implemented spatially separated as far as possible.

3 Inside better sealed than the outside:
Constructions must be able to release more moisture from the air circulation and diffusion towards the outside than penetrates into the construction from the inside.

4 Ensure the opportunities and risks of new materials and technologies:
Tests must be carried out to ensure the suitability of the use of new materials and technologies in the windows and facades industry.

5 Pressure equalisation for reliable discharge (drain) of moisture seeping into the construction:
With the help of pressure equalisation the required rise of water in the construction can be reduced and the watertightness can be improved.

6 Increased glass penetration into the frame:
An increased glass penetration into the frame reduces the risk of condensation at the edging of the glass.

7 Thermal break on one level:
Isotherms running, as far as possible, in a straight line improve the U_f-value

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Born on February 12, 1964 in Elmshorn, Germany

1981 – 1984	Vocational training, Lillich glassworks, Marbach a. N. Qualification: certified glazier/window-maker by trade test
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1992 – 1995	Gebr. Schneider Fensterfabrik, Stimpfach, Project Manager Preuße Metallbau GmbH, Oststeinbeck, Project Manager
1995 – 1996	FET Cord Hatje GmbH, Schenefeld, Project Manager
1996 – 1997	Staff member at ift Rosenheim, function: Head of Testing Department and business line at the
1997 – 2000	ift Centre for windows and facades, Head of the notified testing body for facades (Id.-No.: 0757) Main focus of responsibility: testing of window and facade constructions
since 2000	contributions to the creation of guidelines and standards quality control and certification technical lectures expert statements