

English Summary

To maintain and enlarge the market share of wood windows in Germany it is of essential importance to both evaluate past experience and to provide technical know-how for the future. The normative description for the construction of wood windows as outlined in DIN 68121 has not proven useful. The specifications defined therein were often considered compulsory and thus used as a benchmark for the evaluation of new products.

The interpretation of new findings will have to focus on customers' needs with respect to design, handling and functionality. Within certain technical limitations, window construction will further need to accommodate architects' demands. Current rules and regulations such as DIN EN 14351-1 "Windows and external pedestrian doorsets - Product standard" serve as a reference for the evaluation of physical properties. DIN EN 14351-1 defines common European standards for testing, classification and labeling. Such product standards allow for sufficient flexibility to meet local requirements with regard to design, types of wood and surface treatment.

Decorative types of wood are preferred in a residential environment. However, these may not necessarily be suitable for outdoor use as they tend to be sensitive to weather. Thus, a layer composition of different materials is required. For this study, the suitability of different types of wood and their respective behavior in a cross section has been examined. Further, it outlines the optional usage of different materials.

For various complex reasons there has been a decline in the market share of wood windows for several years, the major issues being the necessary maintenance effort and the materials' change in appearance.

Studies have shown that both residents and architects have begun to use wood more frequently for interior design, thus indicating a possible reversal of the trend. A change in trend can only be achieved if the necessary maintenance effort is kept at an acceptable level and the fitness for use can be maintained for an adequate use period. The average use period for wood windows is 40 years.

The actual use period is usually determined by the fact that the windows no longer meet technical requirements or are no longer considered comfortable to use. In some cases, the use period is terminated by wood decomposition as a result of wood-destroying fungi. Infestation of wood-destroying fungi requires persistent moisture penetration of the wood, mostly caused by the climate either on the indoor or on the outdoor face.

Taking into consideration the influence of humidity requires detailed knowledge of the respective climate conditions both in the outdoor and indoor environment. Weather conditions cannot be controlled. Structural adaptations can, however, reduce the extent of direct weather influence.

Due to the air tightness of the outer walls of the building the air exchange supported by lack of air tightness of the outer shell is no longer given. As a result, the effects on windows caused by indoor environment have increased. The indoor environment causes increased stress on windows which in turn results in condensate on the margin of insulation glass and window rebates.

Tests in rooms showed a relative humidity between 40% to 60%. These figures resemble the annual change in humidity based on a normal to high indoor humidity. Test results further showed that airing a room twice a day by opening the window the relative humidity can only be lowered temporarily.

During the indoor climate tests the window rebates between the wing and the frame were checked. It became evident that during the heating period condensate

in the window rebates was a common problem. Increased stress on the wood was caused by persistent condensate in the lower rebates.

The formation of condensate in the rebates was confirmed in field studies. Factors leading to the formation of condensate and conditions for the avoidance of condensate could be determined.

Tests regarding pressure distribution in buildings confirmed the influence of the interior pressure of a building on the development of condensate in window rebates. Tests did not provide a complete explanation regarding influences on the formation of condensate. The use of sealing on the inside between wings and frames proved to be a vital aspect for avoiding condensate.

Three mathematical models were compared to study the deformation behavior of laminated wood-profiles made from different types of wood. The correlation of the results was similar for all models, therefore the model "single-span girder suspended in two points and influenced by a momentum at the end of the girders" was chosen. In this case, it is possible to calculate the distortion caused by different climates both on the inside and the outside respectively, taking into consideration the relative humidity throughout the year.

Environmental humidity and longitudinal swelling of wood – specified by the swelling coefficient "h" in [% / %] - influence the distortion considerably. The swelling coefficient was the greatest factor of uncertainty in the calculations since other sources provided a great variety of strongly deviating figures.

During the research project the coefficient for longitudinal swelling of wood „h“ was determined for 10 different types of wood. For greater accuracy a work piece not meeting the DIN 52184 standard was selected.

Evaluating the calculations of the distortion in differential climates revealed that the swelling coefficient of the outer segments of the laminated wood-profiles had a greater influence on the distortion of the than the swelling coefficient of the inner segments of the laminated wood-profiles.

Following the objectives of this study, the findings provide several guidelines for users focusing on the following aspects:

- Indoor glass surface temperature
- Condensate on thermal bridges of the notch
- Laminated wood-profiles of different types of wood
- Condensate in rebates
- Condensate in glass rebates