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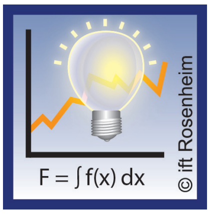
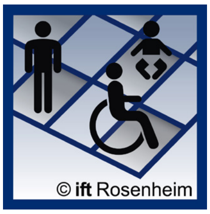
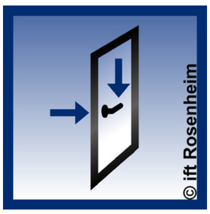
Short Report
June 2018

Evaluating the accessibility and usability of building components using windows and doors as examples







Short Report

Topic	**Evaluating the accessibility and usability of building components using windows and doors as examples**
Short title	Accessibility and usability of building components
Funded by	Research initiative "Zukunft Bau" (on future-oriented construction) of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (File reference: SWD-10.08.18.7-15.08)
Research centre	ift Non-profit Research and Development Company mbH Theodor-Gietl-Straße 7-9 83026 Rosenheim
Official in charge	Sandra Haut Knut Junge Fabian Kutscher Norbert Sack
Project Manager	Norbert Sack
Director of the Institute	Professor Ulrich Sieberath

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1 Motivation and project goal

Many persons are dependent on a barrier-free environment due to the most diverse physical and mental limitations. Based on demographic change, there is also an increasing need for barrier-free solutions to enable independent and comfortable living right up to old age.
The basic goal of accessibility and usability, especially in the public sector, provides for use by as many people as possible with and without restrictions. The newly published standards DIN 18040 1+2 on barrier-free construction, which have been introduced in the majority of the Federal states under building law, are, in fact, already aimed at the respective individual protection goals, but do not contain any specific information or individual recommendations for use. However, this often leads to structural solutions that strive to meet all conceivable normative and regulatory requirements tenaciously, without meeting the actual needs of the user groups in future.

Especially in the private sector, and in special facilities, however, situational fitting of the components is necessary in order to achieve the optimum for the respective user group and, above all, to make it affordable. Apart from this, even the conventional and extremely broadly diversified performance characteristics for windows and doors, should not lag behind.

The goal of this research project was to define barrier-free requirement profiles for the most diverse user groups and applications of windows and doors. For this purpose, concepts were to be developed with which practical evaluation of the accessibility and usability of building components such as windows and doors gets facilitated. The findings of the project are meant to lead to recommendations for use of barrier-free windows and doors.

2 Procedure and results

2.1 Research and analysis

In order to determine the status quo of barrier-free construction, a research was carried out including regulations, recommendations, funding programmes and research projects as well as product research. The needs of various user groups were determined, assigned to the protection goals and specified on the basis of construction-related requirements for windows and doors.

The results of the research established that there is only little information beyond the normative specifications for implementing accessibility and usability with windows and doors . Instead of pointing out alternatives, reference is generally made to power-operated elements. Based on the requirement profiles prepared, the planner is capable of better identification of the actual requirements of the user groups and to meet these with requirements for windows and doors.

At the beginning of the project, the existing solutions of the industrial partners for accessibility and usability with windows and doors were researched. In the course of the research, only those solutions were considered that were available on the manufacturers' websites or in their advertising material, which was easy to find, or which was clearly advertised as solutions for accessibility and usability. The goal was to simulate the search by a planner/builder who still has little knowledge regarding accessibility and usability. Table 1 presents the result of the search.

Table 1 Solutions for accessibility and usability of the project partners at the beginning of the project

	Manufacturer										
Accessibility solutions	1	2	3	4	5	6	7	8	9	10	11
Handles											
Extended handles			x								
U-shaped/arched handles		x	x	x				x			x
Cranked door handles		x									
Vertical handle bars for doors			x								
Handle height 85 cm			x	x				x			
Window handle on the lower window frame											x
Door fitting with locking cylinder above the handle			x								x
Different colours of the handle								x			x
Type of operation											
Opening limit for windows			x					x			x
Thresholds											
Thresholds ≤ 20 mm			x	x		x	x	x		x	
Thresholds < 5 mm	x	x	x		x				x		
Automatic door seal	x	x			x						
Threshold with LED lighting			x								
Power operated elements											
Windows							x	x			
Doors			x				x	x			
Security											
Finger protection	x	x		x							

Regarding accessibility and usability, threshold solutions are the most advertised. Barrier-free thresholds are considered at or below a threshold height of 20 mm. Lifting-sliding doors and revolving doors with sunk floor seals have the least threshold heights. With lifting-sliding doors, the threshold height is defined by the height of the roller track and is usually about 5 mm. When thresholds are used in connection with sunk floor seals, the term "zero thresholds" is used sometimes, but here, too, there are slight differences in level. These then consist of the material thickness of the threshold profile at the transition to the floor cover. DIN 18040-2 primarily specifies the absence of thresholds or thresholds up to 2 cm should represent the exception. Hence, the definition of the "barrier-free threshold" as a threshold with a threshold height < 2 cm, as it is often advertised, must be viewed critically.

Table 2 lists the essential performance characteristics of windows and doors, and interactions of these performance characteristics with the requirements of accessibility and usability are described.

Table 2 Performance characteristics of windows and doors and their interactions with accessibility and usability

Performance characteristic	Interaction with accessibility and usability
Resistance to wind load	With large elements, higher sash weights may lead to larger operating forces due to reinforced profiles and thicker glass panes, particularly while tilting them.
Watertightness	A higher contact pressure and/or other closing and sealing systems may lead to larger operating forces when closing the sash or casement. Barrier-free thresholds may lead to lower watertightness. If a high level of watertightness is required, it becomes necessary to use special sealing and drainage systems.
Hazardous substances	No interference is expected
Height and width of doors and French windows	With increasing element size, the sash weights and thus, the operating forces increase, especially for tilt closing.
Sound insulation	With requirements for airborne sound insulation, the larger weights of sound-proofing glass result in greater operating forces, especially for tilt closing
Heat transfer coefficient	With (large) elements, especially insulated triple glazing, heavier sash weights may lead to larger operating forces, especially for tilt closing.
Radiation properties	No interference is expected
Air permeability	Larger contact pressure leads to a higher air-tightness and hence, it may lead to increased operating forces for closing the sash. Barrier-free thresholds may lead to lower air permeability.
Operating forces	Low operating forces are expressly specified in DIN 18040-2, which means that windows and doors can also be operated by persons with reduced mobility.

Ventilation	There are no interactions here.
Bullet resistance Detonation resistance	These requirements are rather not applicable for residential living. The required reinforcement of such elements may lead to high sash weights and thus to increasing operating forces.
Durability	Continuous accessibility and usability can be ensured only by regular maintenance and functional testing.
Differential climate behaviour	Permanently efficient materials are dimensionally stable for longer periods and thus, they ensure low operating forces for a longer time period. Deformations of the sash due to differential climate may temporarily lead to larger operating forces.
Burglar resistance	There is interaction caused by special fittings with more locking points and the necessary glass structures, thus leading to greater operating forces. In connection with barrier-free thresholds, implementation of burglar resistance may become more difficult.

2.2 Practical investigations

Practical investigations in facilities for senior citizens should show how accessibility and usability is implemented with windows and doors, and whether the standardised requirements reflect the actual requirements. On the one hand, the test subjects were surveyed about barriers in their living environment. On the other hand, a specially developed operating force simulator (Figure 1) was used to determine the operating forces that the test subjects could exercise. The surveys established that turn-and-tilt French windows were often operated only rarely due to excessive operating forces. Even the admissibility of some thresholds was criticised. The limit values for operating forces of finger-operated and hand-operated fittings proved to be too high in practice, while the limit values for linear movement were found to be acceptable. Simple service work has significantly reduced the usability of faulty French windows.

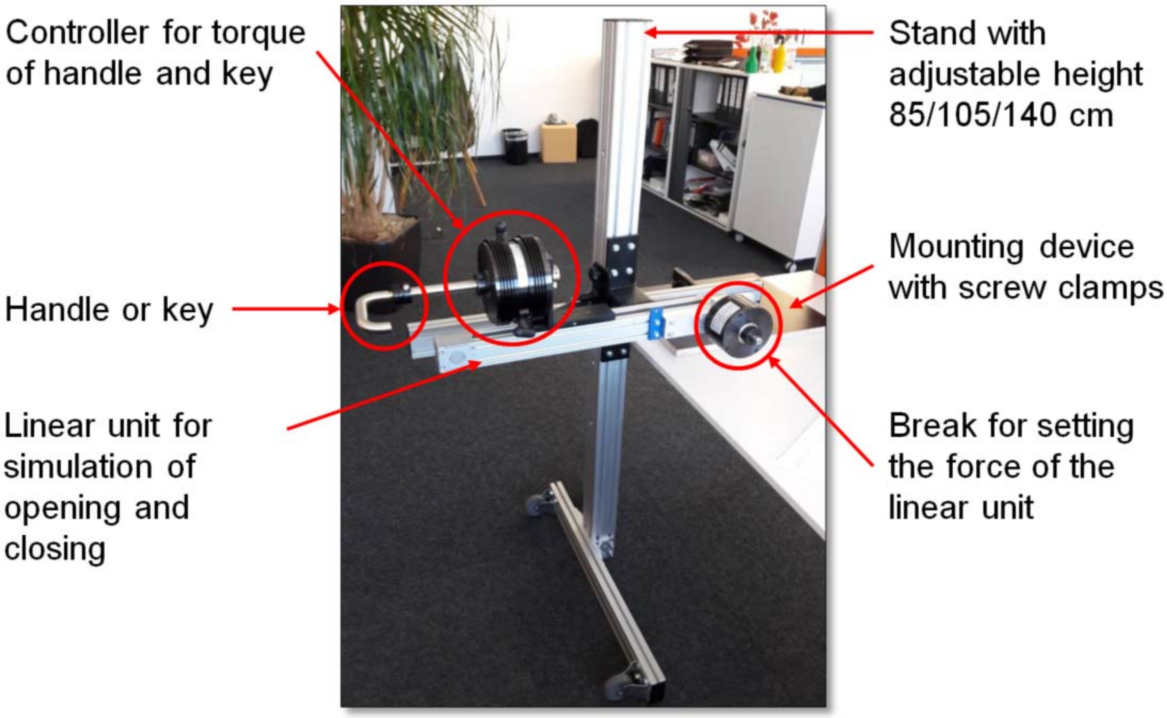

Figure 1 Developed operating force simulator for measuring the possible operating forces of use

2.3 Laboratory tests

Laboratory tests have investigated how operating forces change during the life cycle of an element and which interactions exist between low operating forces and other performance characteristics. Extensive operating force measurements were carried out on windows in order to demonstrate whether the permissible operating forces can be achieved with them. It is seen that the operating forces via the contact pressure have a direct impact on the air-tightness and the resistance to watertightness (Figure 2).

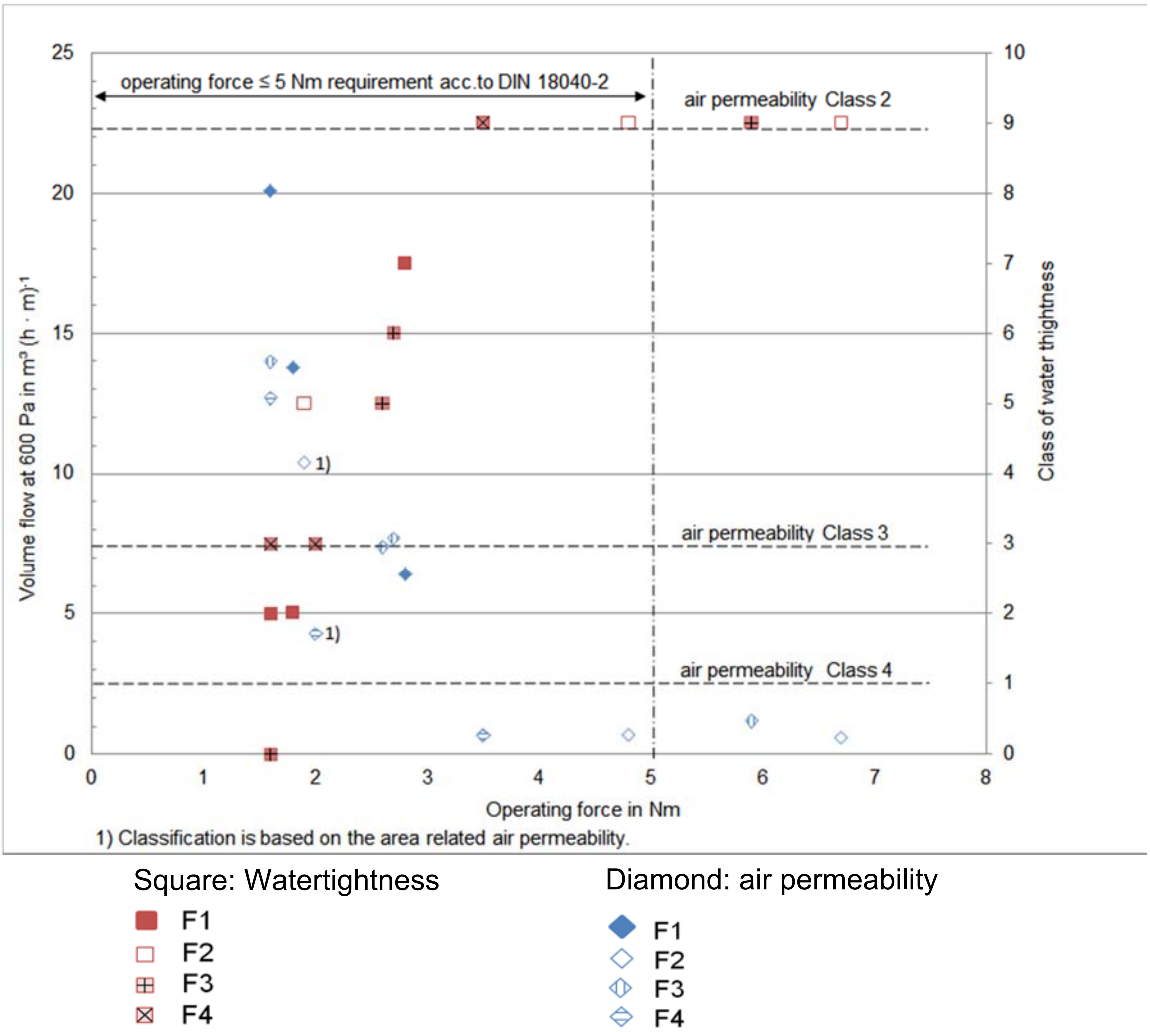

Figure 1 Illustration of the dependency of watertightness and air permeability regarding the operating force for the windows investigated. A falling contact pressure leads to reducing operating forces, but this results in increasing air permeability and decreasing watertightness.

Various additional fittings (Figure 3) may offer an alternative to tilt opening and closing, or facilitate this in such a way that the standard requirements for low operating forces can be met. The operation of tilting for French doors remains critical, but additional fittings may significantly reduce the operating force for tilt closing.

Figure 3 Example of an additional fitting. Single-sash side-hung window with ventilation cleaning stays and easily accessible handle on the lower sash frame profile

In Germany, the threshold height is the sole criterion for barrier-free admissibility, whereby rollover capability is more important, particularly for users of wheelchairs and walking frames. Comprehensive tests were carried out on the ability of rolling over thresholds with a wheel carriage (Figure 4). Based on this, a measurement method was developed and its objective results were compared with a subjective evaluation of the test subjects. The procedure was described in a separate guideline. Thus, thresholds can now be classified with regard to their rollover capability.

Figure 4 Realised trolley for testing the capability of rolling over thresholds. Additional weight 40 kg fastened in the middle of the panel. Position on the moving surface in front of the installed threshold.

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ROSENHEIM

ift Rosenheim
Theodor-Gietl-Straße 7-9
83026 Rosenheim

Tel.: +49 (0) 80 31 / 261-0
Fax: +49 (0) 80 31 / 261-290
E-Mail: info@ift-rosenheim.de
www.ift-rosenheim.de