Bundesministerium
für Verkehr, Bau
und Stadtentwicklung

Bundesamt
für Bauwesen und
Raumordnung

Organisational and constructional measures for managing emergency situations involving physically and sensorially disabled persons in high-rise buildings and public buildings with high use frequency

Abstract

December 2010

This research was supported with resources from the Zukunft Bau research initiative of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) (File reference: SF – 10.08.18.7- 09.6 / II 3 – F20-09-001-051). The author is responsible for the contents of this document.

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1 Goal of the research project

Society's need for barrier-free construction is growing in proportion to the number of its disabled or mobility-impaired members. Accelerated **demographic change** is one of the main reasons why the number of elderly people – many of whom have impaired mobility – is due to increase considerably over the next few years in Germany.

In practice, in both textbooks and technical regulations, barrier-free environments for the "normal" have been given priority up to now. In Germany, due to the existence of systematic preventive measures and efficient rescue systems, few people have been injured in fires and other disasters in buildings open to the public. Nonetheless, such situations, no matter how exceptional, still pose a challenge to disabled persons, and constitute a greater hazard to them than to the non-disabled.

Public buildings are popular destinations (administration, culture, etc.), and due to their size and complex layout often prove challenging to people's directional skills even when they are neither disabled nor elderly. Of course, emergency instructions and maps are supplied in case of fire or other unforeseen situations. However, disabled persons may face special problems in emergency situations, in that it is more difficult for them to save themselves without assistance or raise the alarm.

The Federal Equal Treatment for Disabled Persons Act (Behindertengleichstellungsgesetz, BGG) which came into force in 2002 [4], obliges the Federal State to erect new civil buildings and perform large civil conversion and enlargement work **so as to ensure that the buildings are barrier-free, in accordance with the generally accepted state of the art.** At this point in time, the development of a generally accepted state of the art for barrier-free construction is still under way.

The goal of this research project was to identify solutions by analysing and describing **innovative technical developments** that would facilitate the **management of emergencies involving disabled persons in high-rise buildings and public buildings with high use frequency,** especially in federal buildings. Besides technical measures, **organisational measures** are also a vital component of overall emergency planning.

2 Implementation of the research project

This project was commissioned and funded with resources from the research initiative "Zukunft Bau" of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR). The project was supported by a multidisciplinary work party comprising barrier-free construction experts, spokespersons for disabled persons and members of the fire brigade.

First of all, a thorough analysis was made of the **legal bases,** i. e. the provisions supplied in specifications and technical regulations concerning fire safety and the creation of barrier-free environments, as well as the taking into account of the needs of disabled persons in emergency situations. The consequences of the current DIN 18040-1 standard on "Construction of accessible buildings – Design principles" (October 2010), were reviewed. A future update of the DIN standard may incorporate some of the changes and additions suggested in this project.

In the next stage of the reasearch, a detailed examination was made of the various **requirements concerning the management of emergency situations involving disabled persons**.

Further to intensive screening, a number of **research areas** were identified, and thereafter used as a basis for the **detailed analysis** of a high-rise building and of a large administrative building. This included the identification and documentation of features and measures for the

rescue of persons (especially disabled persons) in emergencies. The specific properties of these features and measures served as a basis for the identification of constructional and organisational measures to improve the safety of disabled persons in emergency situations, and the practicability and transferability of these measures were analysed.

The development of complex **emergency scenarios** (fire, evacuation, individual emergencies) required among others that concrete emergency measures be identified and combined according to local conditions. The choice of buildings and emergency scenarios made it possible to demonstrate that high-rise buildings and public buildings with high use frequency can indeed be made safer by the methodical application of constructional and organisational measures.

A large number of positive examples (best practices) form **the core of this project.** They were analysed and presented as ways in which the management of disabled persons in situations of emergency can be made easier.

The needs of all other (non-disabled) users, as well as economic issues and aspects relating to design, were taken into account at all stages of the project.

3 Summary of the results

3.1 Existing deficiencies in the way requirements are taken into account, and subsequent requirements

The identified requirements of disabled persons were used as a standard in this research project. As a consequence, despite considerable progress, a number of deficiencies in implementation and fulfilment were recorded. Up to now, the requirements of disabled persons in terms of barrier-free design in public buildings have been considered differently for normal situations and emergencies, so that such deficiencies are not simply isolated occurrences such as stiff doors, avoidable split levels, unmarked stairs, and so on.

The federal government's commitment under the BGG, the commissioning of specific research projects, additional specialised public-relations work, the support given to technically based standardisation and, last but not least, practical experiments involving actual construction projects all go to show that the Federal Republic does indeed take barrier-free design seriously. However, a number of deficiencies remain in the following areas:

- The lack of **alarm signals which can be perceived by sensorially disabled persons,**
- The lack of information facilities and **orientation aids along evacuation routes** for sensorially disabled persons,
- The subsequent **application of the 'two senses' principle** (see also [1]) and
- The lack of **barrier-free emergency call facilities.**

When people are expected to manage their own response to an emergency – i.e. follow instructions based on current safety-related requirements – deficiencies are especially apparent in the following areas:

- Compliance with **reliability and quality requirements,**
- Use of appropriate means and methods to improve **subjective safety**
- Appropriate **training** for operating and service staff,
- Installation of barrier-free, **mobile emergency call facilities** and
- Emergency management **drills**.

The following requirement, which is described further on in this document, is partly based on the above deficiencies:

Increased implementation of innovative and effective technical measures.

For economic reasons, and to make full use of people's ability to take responsibility for themselves in an emergency, more innovative improvements need to be introduced – that is, improvements which are already feasible, such as increasing the time during which lifts can be used in the event of a non-critical fire (Figure 1), and which to date have been implemented only sporadically.

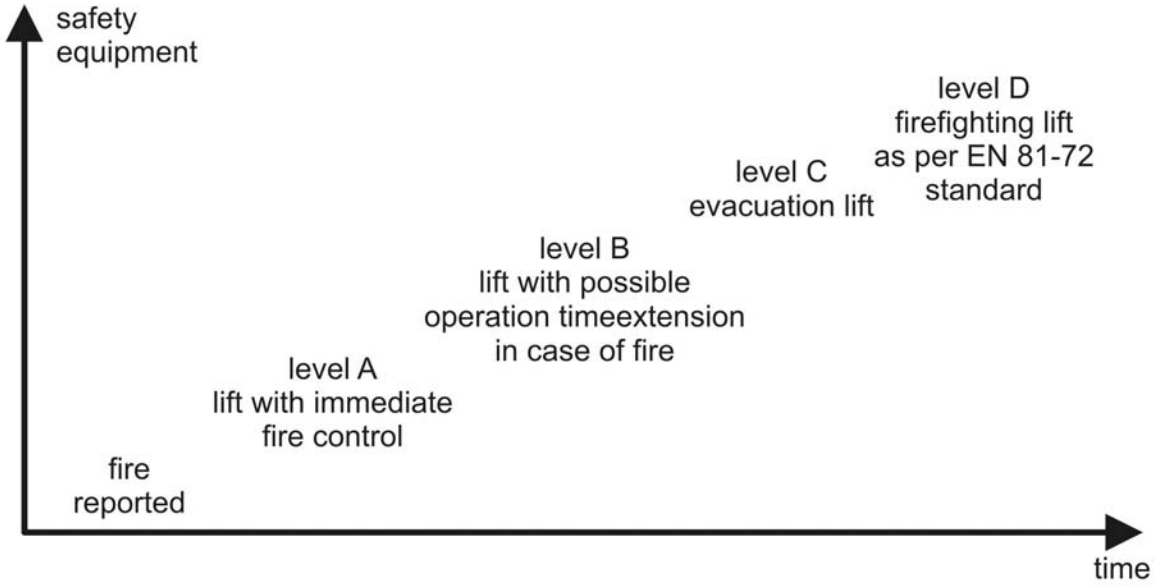

Figure 1: Effects of various categories of lift equipment on the extension of operating time in case of fire [5]

The options for a lift which is safe for all users require further research, and the implementation of the subsequent measures must be encouraged. If disabled persons are able to save themselves, this would enable the primary targets of the preservation of life and physical integrity to be met in emergency situations by means of operational/organisational measures, e.g. a fire protection system.

Supplementation and compensation by means of operational/organisational measures

In order to fulfil requirements based on the current state of knowledge in the case of existing buildings, comprehensive and occasionally cost-intensive measures are required. Retrofit conversion work is extremely difficult or even impossible. In such cases, barriers to access and use must be removed by means of operational/organisational measures whenever possible. When safety requirements are involved (see **Fehler! Verweisquelle konnte nicht gefunden werden.**), such measures and precautions (even when retrofitted) are indispensable.

Figure 2: Evacuation chair – a complementary or compensatory means of transporting physically disabled persons up or down emergency staircases [Photo: Grossmann]

In the case of new buildings, operational and organisational measures also play a vital part in overall emergency management.

Improved contrasting and orientation

As part of a barrier-free design, visual and tactile contrasts need to be increased, especially for information and orientation purposes. The DIN 32975 standard [1] includes concrete instructions concerning visual information. Discrepancies with colour or lighting schemes are avoidable provided this issue is taken into consideration at the early stages.

In this connection, a guideline concerning the use of tactile scripts is required (in accordance with [2] Article 27 Paragraph 1 Sub-paragraph i). At any rate, the formulation of the convention should be reworded so that (embossed) normal print is required as well as Braille (see Figure 2; for further information see [1]).

Figure 2: Tactile script (Braille print) on a handrail [Source: DBSV]

Consistent application of the ‘two senses’ principle

It is essential that the ‘two senses’ principle be applied to safety information, e. g. alarms, warning signals, emergency equipment and signage of evacuation routes (see [1] Table 3/2). This requirement is only partially imposed by specifications and technical regulations.

Further requirements

It should become the rule to review all upcoming building projects to determine whether measures to remove or reduce barriers for the purpose of emergency management can be cost-effectively implemented.

3.2 Innovative improved emergency-management measures (best practices)

The main task of this project was the systematic review and presentation of feasible improvements.

The measures listed in this document are the result of intensive and comprehensive research, and are intended to improve the situation of disabled persons in emergencies. In addition to specific high-tech solutions, this list also includes a number of practicable measures in various areas, which can be implemented using tried-and-tested conventional technology. In practice, many of these measures have remained little-known and little-used. Our research and complementary investigation show that many seemingly excellent solutions are often underpinned by faulty and misguided assumptions. In many cases, these assumptions are also fragmentary. In some cases, complementary investigation was required for credible assertions to be made concerning specific areas of application.

The purpose of presenting these measures is to supply concrete advice for the application of improvements to future and existing buildings. In each case, each of these measures must be integrated into an overall concept.

To reduce existing problems, i.e. to remove barriers, it is either necessary or advisable that measures be taken in the following areas, usually in combination:

- Constructional measures,
- Fittings (special technical measures),
- Operational and organisational measures, as well as
- Individual measures.

The many interesting and effective best practices include:

1. Evacuation chutes,
2. Fireproof rooms for waiting,
3. Construction of (safe) fire areas in historic buildings,
4. Safe mustering areas,
5. ‘Transparent architecture’,
6. Ramps with handrails in historic environments,
7. Long (evacuation) ramps for access purposes,
8. Avoidance of vertical evacuation routes,
9. Central areas with short evacuation and rescue routes,
10. Lifts with improved fire control,
11. Navigation and assistance systems which use RFID[1]/GPS technology,
12. Dynamic, voice-operated evacuation and guidance along evacuation routes,
13. Dynamic, optic evacuation and guidance along evacuation routes,
14. Dynamic guidance along evacuation routes,
15. Evacuation chairs,
16. Mobile emergency phones and wrist alarms,
17. Use of sensor mats,

[1] RFID = **R**adio **F**requency **Id**entification; RFID enables objects and living beings to be automatically identified and located. For instance, RFID chips could be used to mark a ‘virtual route’ electronically.

18. Automatic door-opening systems operated by sensor mats (with sliding smoke doors),

19. Lift alarm with video surveillance,

20. Highly contrasted relief maps (sheets) which incorporate evacuation and rescue routes,

21. Highly contrasted depictions and tactile signage of evacuation and rescue routes,

22. Improvement of orientation by means of highly contrasted signage of building areas,

23. Individual orientation and mobility training (O & M),

24. Access control/supervision,

25. Signage of evacuation routes for mobility-impaired persons,

26. Visual alarm signals,

27. Supply of individual communication equipment,

28. Smoke alarm systems for hearing-impaired persons,

29. Individual mobile alarm systems for the hearing-impaired persons,

30. Evacuation drills with participation of disabled individuals,

31. Highly contrasted tactile model with evacuation and rescue routes,

32. Special assistance by staff members for disabled persons,

33. Staff training,

34. Limitations on use of function rooms/baby carriers.

The results of the research are supplied in the form of overview tables (see example in Table 1). This enables planners, operators and other interested parties to:

- Gain an idea of up-to-date, effective potential solutions, especially of innovative measures, and/or
- Find improvement measures for concrete situations among the positive examples supplied.

We suggest setting up a database which is both easy to access and understand in order to disseminate these positive examples. The data collected in the course of the research project could be used as a basis. Further improvements in these areas are to be expected in the near future, so that this database would need to be maintained, i.e. regularly updated. In order to reach the relevant target groups, especially the planners and operators involved in the construction of federal buildings, seminars should be organised on the subject of barrier-free construction (see for instance [8]), with particular emphasis on “Safety issues – Potential improvements to emergency management“ and other points.

Table 1: Example of a conventional improvement measure: 'transparent architecture'

Place (example):	- Bonn, Deutsche Welle broadcast studio - Bonn, Post Tower		
Status: applied	**Type: B[2]**	**Use by: PD, VI, HI [3]**	**Scenario: IE, FI, EV[4]**

[Photo: Grossmann]

Summary

Buildings can be designed and built so as to be 'transparent'. This requires the plentiful use of glass. As a result, most places in the building have an outside view as well as views of other corridors and rooms. This makes it easier to locate individual emergencies promptly, as well as, should it be necessary to evacuate the building, people who have been left behind or require assistance.

This was achieved in narrow sections of the building in which rooms with outer walls were grouped on either side of corridors. By installing panes of glass between the corridors and rooms, it became possible to look directly into the rooms from the corridor and vice versa, as well as to look outside from both corridors and rooms. This considerably improved orientation, minimised the fears of a number of population groups, and shortened evacuation and rescue routes.

Transfer	Transferability	Listed buildings	Retrofitting
	+	0	-
Specific drawbacks / advantages	+ Improves use for all (e.g. also for mental patients) + Short evacuation and rescue routes throughout the building complex – Needs to be taken into account at an early stage in the planning; retrofit very difficult as the building structure will require appropriate conversion – Transparency increases invasions of privacy		
Requirements for further research			

3.3 Conclusions

In the course of this research project, requirements, existing framework conditions and potential improvements to the management of emergency situations involving physically and

[2] Type B = Construction-related measure

[3] PD = Physically Disabled, VI = Visually Impaired, HI = Hearing-Impaired.

[4] IE = Individual Emergency, EV = Evacuation, FI = Fire.

sensorially impaired persons in high-rise buildings and public buildings with high use frequency were analysed concurrently, systematically and in depth. In the case of federal new civil buildings and of major conversion or extension work on such buildings, barrier-free design in accordance with best practice is mandatory. The consequences of the current version of the DIN 18040-1 standard, "Construction of accessible buildings - Design principles" (October 2010) were also taken into account. Above all, a large number of innovative measures were investigated, analysed and listed. Whether as individual measures or used in combination, they can considerably improve emergency management for disabled persons and/or help improve profitability. Many of the recommended measures are also useful for the non-disabled, especially as the same basic safety requirements are applicable to all. Special attention was paid to federal construction projects. The resulting recommendations are usually transferable to other buildings open to the public.

These positive examples include technical innovations, appropriate conventional construction-based solutions and organisational measures. The results are organised in such a way that they are suitable for transfer to an easily accessible database. This document lists many interesting and effective best practices, for instance the improvement of fire control for lifts and the participation of disabled persons in evacuation drills.

To ensure the sustainability of construction-related and organisational precautions, ancillary measures are also required, such as targeted public-relations and professional public-relations campaigns.

The results of the research form a solid basis for the implementation and extension of innovative improvements to the management of emergencies involving disabled persons, and therefore make a sizeable contribution to the self-determined and safe use of public buildings by disabled and mobility-impaired persons.

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