CONSIDERING THE REQUIREMENTS OF HANDICAPPED PEOPLE FOR EQUIPMENT AND OPERATION OF ROAD TUNNELS

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ABSTRACT RÉSUMÉ

STUVA was commissioned by the German Federal Highway Research Institute (BASt) to identify the requirements of disabled and handicapped people and make proposals for practicable and realisable solutions (under practical and economic consideration) for future design and operation in road tunnels and. In a second research project the effort to open emergency doors in road tunnels considering the requirements of handicapped people was examined. Both projects had to take the special situation in road tunnels into account and should give hints for quick actions and a revision of national standards, e. g. RABT 2006 by the German Road And Transportation Research Association [1], which is based on EU-directive 2004/54/EC “Minimum safety requirements for tunnels in the Trans-European Road Network [2].

STUVA a été commandée par l’Institut de recherche route fédérale allemande (BASt) pour identifier les besoins des personnes handicapées et à mobilité réduite et faire des propositions pour des solutions pratiques et réalisables (à l'examen pratique et économique) pour la conception et le fonctionnement dans les tunnels routiers et. Dans un deuxième projet de recherche de l'effort d'ouvrir les portes de secours dans les tunnels routiers compte tenu des besoins des personnes handicapées a été examiné. Les deux projets ont dû prendre la situation particulière dans les tunnels routiers en compte et devrait donner des indications pour des actions rapides et une révision des normes nationales, e. g. RABT 2006 par l'allemand Transport routier et l'Association de recherche [1], qui est basé sur directive européenne 2004/54/CE "exigences de sécurité minimales applicables aux tunnels du réseau transeuropéen de réseau routier [2].

1. INTRODUCTION

Guarantee and continuous improvement of security of road tunnels is an important and generally accepted objective. Demands of providing safety conditions not only cover new planned tunnels, but also retrofitting existing tunnels. The consideration of the needs of handicapped people (handicapped people includes also elderly people and children) in emergency cases in road tunnels is a basic right and important part of guaranteeing an autonomous mobility to the greatest possible extent. This fact gains more and more importance with an increasing number of elderly people in many countries. Measures to improve the safety of handicapped people will benefit all users of road tunnels, because in emergency case every one of us is some kind of handicapped.
When driving through a road tunnel handicapped people could possibly come into an emergency case or have a break down, maybe without having any assistance nearby. This could lead to difficulties to make an emergency call or get help, depending on the layout of the tunnel and its emergency facilities and the design of interior equipment: the accessibility of the emergency walkway and therefore reachability of emergency equipment, the accessibility and usability of emergency equipment (e. g. SOS cabins, SOS

telephone) or problems to open emergency doors and reach the cross cut and the emergency tunnel.

2. REQUIREMENTS OF HANDICAPPED PEOPLE AS TUNNEL USERS

If we take the requirements of elderly people and children into account, a good deal of the population comes with some kind of handicap (in Germany it's actual about 40 % of the population).

With reference to safety of moving traffic and also to handle certain events (break-down, accidents, fire), the requirements of non-handicapped people basically match with those of handicapped people. Structural and organisational measures such as

- short and safe escape routes,
- fire detection and ventilation systems,
- quick information in breakdown situations as well as
- tactical emergency management plans

bring benefit to non-handicapped as well as handicapped persons. Furthermore disabled people have advanced requirements, e. g. regarding design of escape routes or the kind of information given. To some extent for different groups of handicapped people different criteria are relevant. It is obvious that for wheelchair users other features are significant than for partially sighted people. Even when looking at one group alone, requirements differ in a strong way, according to individual skills.

2.1. Wheelchair and walking frame users

Wheelchair users and more and more users of walking frames have some special requirements concerning the design of public space and for that also the design and operation of road tunnels. Those people

- Need more space to navigate in front of doors or e. g. emergency equipment (such as emergency buttons aso.),
- A minimum width of doors and pavements,
- Have difficulties to get over kerbs or ramps (walking frame users have even bigger problems to get over kerbs),
- Have special requirements concerning grasping objects, effort and sight on objects,
- Need a certain amount of time to get out of the car and
- Need more time to cover the distance between car and emergeny equipment.

At present, in German road tunnels pavements are built with a width of 1.0 m and kerbs with a height of 7 cm according to the technical standards. This height could not (or only with great effort or danger for themselves) overcome by wheelchair or walking frame users. The width of the pavement is adequate for usage of this group, if they would only go straight. But if there is a need to turn in case to reach emergency equipment or open escape doors, the movement area is inadequate. It should be 1.50 m X 1.50 m referring to German national standards of barrier-free design.
When wheelchair users have overcome the escape door, they could face another problem: Escape tunnels often have an ascending slope on long distances. Referring to German national tunnel standards 10 % inclination are allowed. Most wheelchair users could overcome 6 % inclination over a short distance as maximum.

Alternatively handicapped people could wait behind escape doors in safe areas (which should not be trapped anyway!) instead of using the escape tunnel. In that case adequate measures such as barrier-free waiting areas and equipment for surveillance and barrier-free communication with control units are necessary.

2.2. Deaf and hearing impaired people

Deaf and hearing impaired people face special problems when getting into an emergency in a road tunnel. They have problems to listen to or understand (due to echoes or mush) acoustical information (announcements, alerts) given by the tunnel staff or by other people. People with hearing impairments normally need visual information.
Another problem of this group could be a lack of fluency (speaking as well as writing/reading). If so, those people have often problems to communicate to other people. A lot of hearing impaired prefers sign language instead of writing.
People with hearing impairments have the following requirements

- The kind and quality of acoustical information given (understandability, quality of public address systems) in conjunction with
- Reducing mush,
- Inductive hearing aid systems.

Deaf and went deaf people need

- Visual information instead of acoustical information,
- The possibility to make emergency calls without use of acoustical language.

2.3. People with speech impediments

Speech impediments have serious impacts on communicating with other people. When speaking without hearing, it sounds to third parties often distorted, inapprehensible and inarticulated. Speech impediment also covers lingual titubation. People with any kind of speech impediment require alternative forms of communication. This has an impact on fixed as well as mobile emergency equipment. E. g. up-to-date mobile phones allow giving information via SMS or e-mail. Many break down services or rescue services offer automated or prepared emergency calls via SMS or application (when using smartphones). At the time in most road tunnels the use of mobile phones is not yet supported. In this context the intended rollout of the automatic E-Call (Emergency call) all over Europe could be another helpful solution for this group of handicapped people, but also for other groups.

2.4. Partially sighted people

A lot of people (especially elderly people) have a reduced mesopic vision, a higher sensitivity to light or an impaired colour vision. Even normally sighted people have a reduced mesopic sight, normally only 50 % of photopic vision. This could lead to problems when driving through a road tunnel and has effects on

- High-contrast design of emergency exits, escape routes and emergency equipment,
- Illumination,
- Kind and quality of visual information given,
- Support by acoustical information, if applicable.

Illumination should balance the requirements of people with reduced mesopic sight and those with sensitivity to light. The adaption zone (when entering the tunnel) with high level illumination is of particular importance for all drivers. A barrier-free design requires

optimised contrasts and colouring, e. g. for signs, service and emergency equipment and escape doors. Combination of certain colours should be avoided (e. g. green and red), because a lot of people suffer from limited red/green sight. Font sizes should not fall below a certain value (the size depends on the illumination and distance between viewer and object) to guarantee readable information (especially important in emergency case with a need to make quick decisions).

2.5. Blind and high-grade visually impaired people

Blind and high-grade visually impaired people have normally assistance because they have not the ability to drive a car by their own. But the escort could be a person who is not familiar with the handicap. In general one could suggest that the driver or a third party person would assist the blind man when facing an emergency case in a road tunnel. Anyhow there could be the case that the driver is injured and a blind person has to get out itself or request for help. This results in the following requirements of blind and high-grade visually impaired people to design and operation of road tunnels:

- Tactile or acoustical information in addition to visual given information,
- Quality of acoustical information,
- Tactile elements to improve orientation when following escape routes,
- Support by acoustical information, if applicable and reducing mush.

Tactile elements should therefore mark emergency exits. The installation of coherent tactile paths (like used on platforms) would be not very practicable. Marking different facilities or devices could lead to misunderstanding, because number of structures and therefore the recognisability is limited. From surface construction the use of tactile elements to improve the orientation, e. g. on handrails or signs, gained good experiences. Push buttons and handrails belonging to escape routes in road tunnels could help blind and partially sighted people to find their way.
Another support could be given by acoustical signals, e. g. speakers above emergency exits, which could be helpful to find the direction to flee. Acoustical information about the situation and instructions how to behave should be given in good quality. Especially blind and partially sighted people rely on acoustical information only.

2.6. People with other mobility restrictions

To build barrier-free as much as possible not only benefits handicapped people, but also children, elderly people or people with long-time or temporarily mobility restrictions. Children and many elderly people for example suffer for low strength which could have an impact on opening emergency doors. In general the requirements of people with other mobility restrictions go not beyond the requirements mentioned above. In many cases requirements are similar to those of handicapped people. This depends a lot of the individual constitution.

3. SPECIFICATION OF EMERGENCY SCENARIOS IN ROAD TUNNELS REGARDING REQUIREMENTS OF HANDICAPPED PEOPLE

For systematic description and analysis of emergency cases creation of emergency schemes proves a failure. Not every possible emergency case could be examined. For the research project three emergency schemes were generated:

- Scenario 1: Break down or accident in the road tunnel without fire;

- Scenario 2: Break down or accident in the road tunnel with fire;
- Scenario 3: Congestion/traffic block in the road tunnel, maybe by fire

The following should give an example of the idea behind. The following figure shows a macrostructure of “Scenario 1: Break down or accident in the tunnel without fire”. This simple scenario could help to give an idea what is behind:

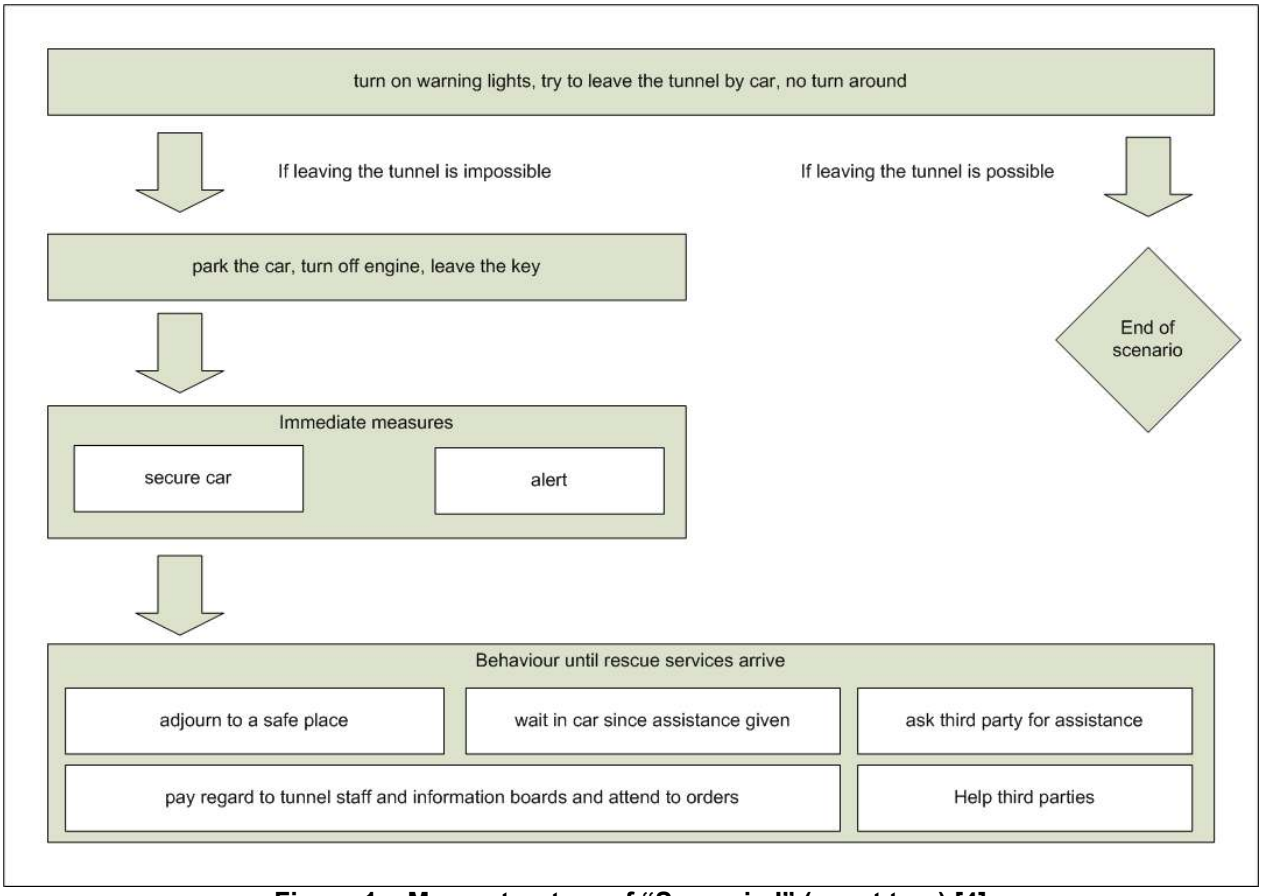

Figure 1 – Macrostructure of “Scenario I” (event tree) [4]

The scenario describes a situation where minimum one handicapped or mobility restricted person gets into emergency case because of break down or accident. The event tree shows how to behave right in an emergency case (based on Safety Information Sheet of BASt [3]). From this model case deviations with their outcome could be considered and requirements for every situation could be planned and examined.

The evaluation of the three mentioned scenarios led to the following findings, which elements of road tunnels had to be into account to match the requirements of handicapped people:

- Carriageways, shoulders, vehicle turnouts: areas for leaving the car and area for movement,
- Escape pavements as escape routes and areas for movement,
- Emergency exits, escape routes and secure areas,
- Emergency call equipment,
- Instruction, orders, signs as well acoustical as visual.

If there are economical or technical hindrances to gain large-scale barrier-free design, at minimum solutions with less barriers should be implemented. Furthermore it is of vitally

important to take complementary measures into account (operational, organisational and other complementary measures).

4. STRUCTURAL AND OPERATIONAL MEASURES CONSIDERING THE REQUIREMENTS OF HANDICAPPED PEOPLE

4.1. Preliminary note

Construction and operation of road tunnels has to fulfil high security standards. Nevertheless all measures are subject to technical-economic conditions. The technical standards and tunnels in Germany have already reached a high security standard, which lead also to a high-level security for handicapped people (e. g. all the time manned tunnel control units, CCTV, automatic blocking in emergency cases, noise reduced emergency cabins aso.). The proposals made from the findings in the research project to improve the safety of handicapped people in road tunnels were analysed and rated in terms of

- Improvement of safety for handicapped tunnel users,
- Improvement of safety for tunnel users in general,
- Applicability from operational view,
- Applicability from technical-economical view for retrofitting tunnels,
- Applicability from technical-economical view for new tunnels.

This rating led to a matrix with recommendations concerning those above mentioned points. Because of the rating, some measures were not suggested, e. g. such as

- Extension of cross section,
- Retractable ramps to overcome kerbs, stairways or sleepers,
- Barrier-free accessibility and usability of emergency cabins,
- Possibility for hearing impaired or deaf to use sign language when talking to tunnel staff.

The following paragraphs show only some examples for the suggested measures.

4.2. Pavements

Pavements in road tunnels are part of the escape routes. Currently pavements are built with a width of 1.0 m, kerbs with a height of 7 cm. To improve the accessibility of pavements especially requirements of wheel chair and walking frame users have to be considered (see section 1). Therefore the kerb should not be higher than 3 cm. Near emergency exits the necessary areas for movement should be installed (see Figure 2 and Figure 3). A dropped kerb of 0 cm was not seen as practicable because of the necessity to drain off dangerous liquids.

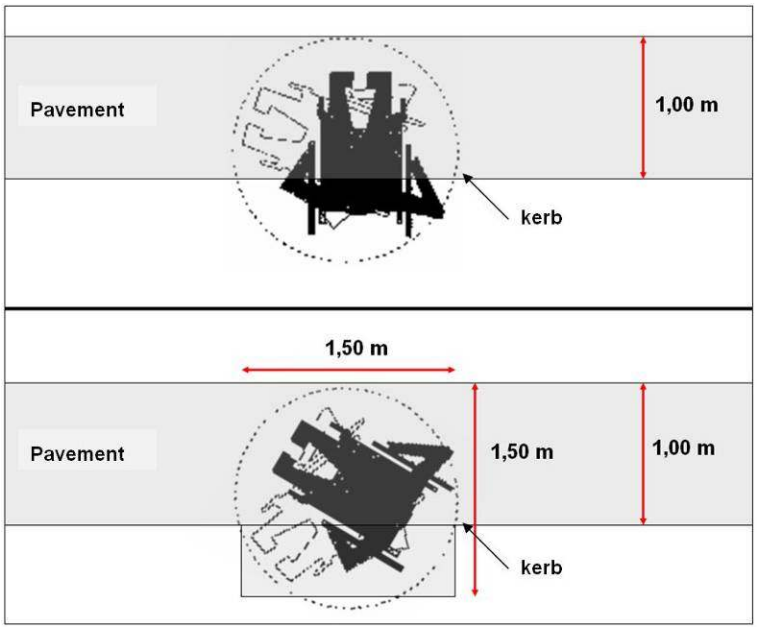

Figure 2 – Necessary areas for movement when wheel chair user enters pavement [4]

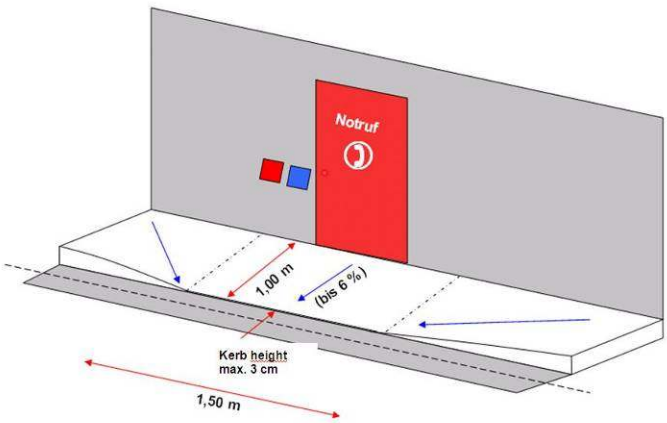

Figure 3 – Recommendation of dropped kerb (max. 3 cm) in front of emergency exit to improve escape routes for wheelchair and walking frame [4]*

4.3. Tactile elements in front of exit doors

Not only for blind and partially sighted people, but also for everyone when moving in a tunnel filled with smoke, tactile elements in front of escape doors could help to find the way. The width of the tactile area should be 1.50 m minimum, i. e. the width of the exit door. The surface should differ form the surrounding surface of the pavement to make those areas detectable easily for everyone moving over it. To avoid irritation, tactile elements should only be used in front of exit doors. The orientation along the escape route could be achieved by markers, fluorescent strips etc. Tactile elements have to be accessible to wheel chairs and walking frames. It has to be avoided to build obstacles for one group when building assistance for another one.

* This was one recommendation in the final report of the research project. After further discussion German road administration decided to build an end-to-end 3 cm kerb. Technical standards will be adapted shortly.

Figure 4 – Example for tactile elements to be used in front of exit doors (test area during the research) – accessibility by wheel chairs is a must

4.4. Special areas for sheltering

Areas behind emergency exits are fire proof and smoke-proof areas. They are able to give shelter for people until the rescue services arrive. Those areas have to be accessible to everyone who is using the tunnel. Even if all escape routes come with barrier-free design, such areas could be helpful, e. g. if fleeing people need to rest or if people are injured and continuing the escape is not possible. Dead-end shelters are not recommended. It has to be possible in any case of emergency to rescue people from one side or the other. Shelters should be build aside escape routes to avoid obstacles for other fugitives. The following equipment should be in such a shelter (selection):

- Floor-plan with escape routes and obstacles
- Barrier-free equipment for emergency calls and communication with tunnel staff (with automatic locating),
- CCTV,
- Seats (min. two) aso.

The floor space required should be 1.50 m x 4.0 m plus space for equipment (e. g. seats). This floor space is adequate to two wheel chair users including assistance.

4.5. Barrier-free accessibility to emergency calls

The barrier-free accessibility of cabins to make an emergency call could only be realised with an enormous technical-economic effort. Furthermore it is no practicable solution when retrofitting tunnels. A much easier solution could be to mount barrier-free push buttons for emergency call outside the door of the cabin (Figure 5). They should be mounted at an height of 85 cm to guarantee the accessibility to all users. The maximum effort to operate those push buttons should not exceed 2.5 N. It would be practicable to install different push buttons for different emergency calls (e. g. break down, fire, accident).

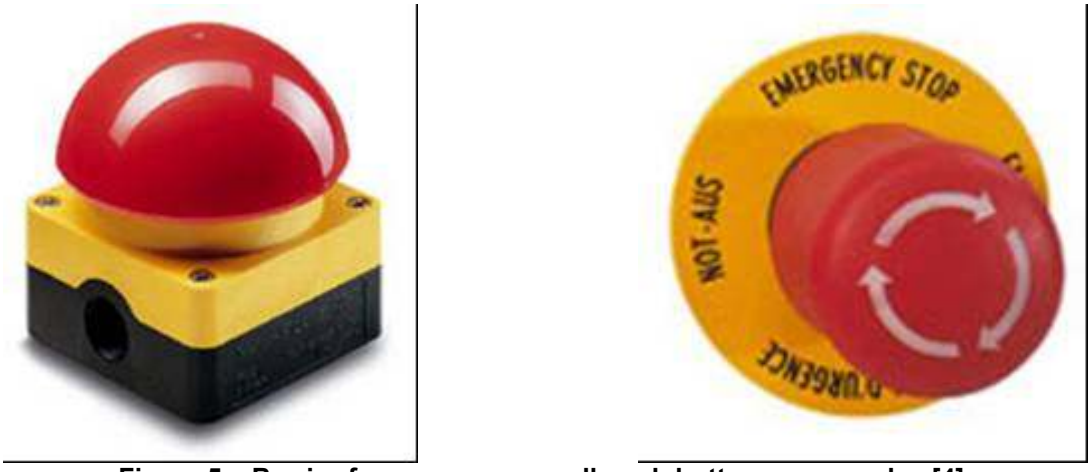

Figure 5 – Barrier-free emergency call push buttons – examples [4]

5. REQUIREMENTS OF HANDICAPPED PEOPLE WHEN OPENING EMERGENCY DOORS

A special problem handicapped (also elderly people and children) face when getting into an emergency case is to open the fire and smoke protecting doors. German national tunnelling standards recommend a force not more than 100 N for opening emergency exit doors. In German tunnels swing doors are common used doors for emergency exits. People with handicaps or elderly people and children may not be able to apply enough power to open those those doors. Another research project should quantify the power people with different handicaps could effort when opening fire protection doors (like used in road tunnels) and identify handicaps which could make opening doors difficult.
Therefore a special test station was build where doors with different resistance (100 N, 70 N, 40 N, 25 N) could be mounted. 15 test persons with different handicaps had to try to open doors with different resisting power (Figure 6).

Figure 6 – Handicapped person on test circuit to scale the power one could effort to open fire protection doors in road tunnels [5]

The evaluation of the tests has not yet been finished (it will be at the end of April 2011). The results of the tests will lead to recommendations for updating the technical standards

and a check-up for the technical solutions of current emergency exits in German road tunnels.

6. SUMMARY

Road tunnels in Germany have a high safety standard available. Events with serious consequences occur fortunately seldom. Handicapped people (including children and elderly people) could possibly come have the need to ask for assistance or have to get out the tunnel by themselves when having a break down or during an emergency. The infrastructure does not meet the special requirements of those groups in some important points. Two research projects handled by STUVA lead to recommendations for the layout of new road tunnels or when retrofitting existing tunnels. The German Federal Highway Authority started to design tunnels considering the needs of handicapped people yet, e. g. by implementing tactile elements in front of emergency exits, improve the accessibility of escape routes and push buttons. The aim is to improve the safety of every tunnel user.

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